Read Thermodynamics Chem.

CHEMISTRY

OHIO STATE UNIVERSITY
OCT 25 1949
LIBRARY

OCTOBER
1949

Thermodynamics 1

Back Cover Picture:
Energy is Paramount 7

Seek New Sources of Cortisone 8

Oil From Coal and Shale 12

For the Home Lab:
Milk Products 15

Your Bookshelf:
Basic Chemical Reference Books 18

What We Know About the Atom II.
How Spectrum Lines are Measured 19

Gold by Magnetic Separation 31

Classic of Chemistry:
First Analysis of Petroleum 37

Frivolous Effervescence and Caustic Comment 42

Coal Hydrogenation Simplified 43

Chemistry Will Change World 45

25¢

Twenty-third Year

A SCIENCE SERVICE PUBLICATION

—*Herblock in the Washington Post*

CHEMISTRY

Vol. 23, No. 2 Formerly The Chemistry Leaflet October 1949

Including The Science Leaflet

Published monthly, September through May, by Science Service, Inc., the non-profit institution for the popularization of science. Publication Office: 119 South Frazier St., State College, Pa. Entered as second-class matter at the Post Office, State College, Pa., under Act of Congress of March 3, 1879. Address communications to the Publication Office; or to the Editorial Office: 1719 N Street N.W., Washingtin 6, D.C.

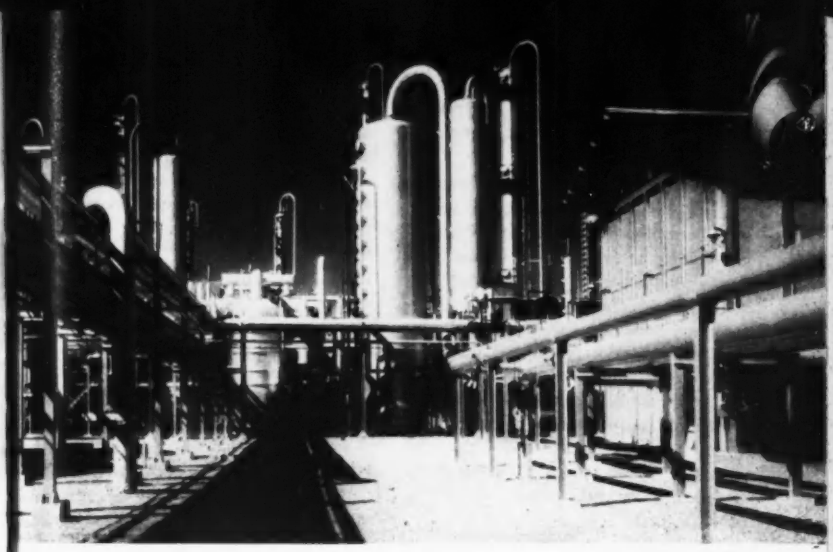
$2.50 a Year; Two-Year Subscription $4; Your Own and a Gift Subscription $4. 25c a Copy. $1 a Copy for May issue. Ten or more subscriptions to the same address: $1.75 a Year each, 15c each Copy each Month, except May, 60c Copy. No charge for Foreign or Canadian Postage.

Editors: WATSON DAVIS and HELEN MILES DAVIS

Consulting Editor: PAULINE BEERY MACK (Editor 1927-1944)

Copyright 1949 by Science Service, Inc. All rights reserved. Science Service issues press service for newspapers and magazines, publishes Science News Letter (weekly), issues THINGS *of Science* (monthly) and administers Science Clubs of America.

Science Service is the educational and scientific institution organized in 1921 as a non-profit corporation with trustees nominated by the National Academy of Sciences, the National Research Council, the American Association for the Advancement of Science, the E. W. Scripps Estate and the Journalistic Profession.



➤ PETROLEUM *chemistry in operation occupies outdoor apparatus built for continuous processing, like this recovery and purification unit at the Chemcel plant of the Celanese Corporation of America at Bishop, Texas. Thermodynamics furnishes the key to planning and carrying out chemical reactions on such a complicated scale.*

Thermodynamics

by FREDERICK D. ROSSINI

As retiring president of the Washington Academy of Sciences, Dr. Rossini of the National Bureau of Standards described for his fellow scientists the theoretical background of his fundamental work with hydrocarbons. A portion of that talk, reprinted here from the Journal of the Washington Academy, explains the energy changes which underlie all chemical reactions from sputtering to fission.

➤ THERMODYNAMICS provides laws that govern the passage of energy from one system to another, the transformation of energy from one form to another, and the utilization of energy for useful work. These same laws also govern the change of matter from one molecular or atomic species to another.

All matter of specified composition, in given electrical, magnetic, and gravitational fields, may be considered to have five fundamental thermodynamic properties—pressure, volume, temperature, energy, and entropy. Knowledge of the proper manner of applying the laws of thermodynamics to these fundamental properties of

CHEMISTRY HALL LIBRARY

substances permits one to subject all transformations of energy and matter to the powerful scrutiny of thermodynamics.

Every physical process or chemical reaction, including biological ones, may be examined thermodynamically. However, the fruitfulness of such examination depends greatly upon the extent to which are known the fundamental properties of the initial and final states of the process or reaction. If the energy and entropy are known, with respect to appropriate reference points, for all values of pressure, volume, and temperature to be covered in the investigation, then the thermodynamic examination can be a complete one.

When under given conditions a chemical reaction takes place of its own accord, it is because the ensemble of atoms and molecules has an opportunity of improving its over-all situation with regard to energy and entropy. In the final state of a naturally ocurring reaction or process, the atoms become arranged in molecular forms that have a more favorable combination of lower energy and higher entropy than in the initial state.

Calculating Results

Given certain initial and final states of a proposed chemical reaction, it is frequently desirable to ascertain, without possible costly experimentation, what will be the amounts of the reacting material in the initial and final states, respectively, at thermodynamic equilibruim under the specified conditions. With known data on the changes in energy and entropy between the two states, under the given conditions of pressure, volume, and temperature, thermodynamics permits calculation of the amounts of material in the two states at equilibrium. If the amount of the material in the final state at equilibrium is large, the proposed reaction has a favorable equilibrium under the given conditions.

Another illustration of the power of chemical thermodynamics is the following: Given 10 possible products which may be formed from one starting substance, what are the amounts of the starting substance and of each of the 10 possible products at equilibrium under the specified conditions? With a knowledge of the difference in energy and in entropy between the starting substance and each of the 10 products, one can answer this question with confidence, without experimentation on the complex reaction involved.

In the foregoing examples it is important to note that thermodynamics does not evaluate the rate at which the given equilibrium concentrations or amounts are reached, does not specify the mechanism by which the molecules are transformed from the initial to the final state and vice versa, and does not disclose any information regarding the details of the molecular structure of the molecules involved in the reaction.

The rate at which molecules pass from the initial state to the final state, and vice versa, in a given chemical reaction is determined by the energy of activation and the temperature. The rate of a specified reaction increases with increase in temperature and with decrease in the energy of activation. By means of a suitable catalyst, the energy of activation can

be very materially reduced, producing a correspondingly large increase in the rate of reaction. The function of a catalyst is primarily twofold—to increase the rate of reaction and to guide the reaction along the desired course.

There exists a property of every thermodynamic system called its energy, E, which is characterized by the fact that it is fully conserved over all systems in every process. The existence of energy is manifested to us through observations of the changes which it produces in material things. The various kinds of energy with which we are familiar include heat energy, mechanical kinetic energy, mechanical potential energy, electrical energy, and radiation energy.

Different processes have associated with them quite appreciably different amounts of energy. The following examples illustrate the tremendous variation in the magnitude of the changes in energy which accompany different processes.

Processes involving changes in the nuclei of atoms.—In the nuclear fission of uranium 235 with 1 neutron to form barium, krypton, and 3 neutrons,

$$U^{235} + n^1 = Ba + Kr + 3n^1,$$

the energy given up by the system to the surroundings is approximately 4×10^{12} cal/mole.

Processes involving changes in the valence electrons of atoms or molecules.—In the recombination of an electron with a proton to form a neutral hydrogen atom,

$$e + H^+ = H,$$

the energy given up by the system to the surroundings is about 3×10^5 cal/mole.

Processes involving changes in molecular structure.—In the reaction of hydrogen with oxygen to form water,

$$H_2 + \tfrac{1}{2}\, O_2 = H_2O$$

the energy given up by the system to the surroundings is about 6×10^4 cal/mole.

Processes involving changes of state, as from solid to liquid or liquid to gas.—In the condensation of water vapor to liquid water,

$$H_2O\ (\text{gas}) = H_2O\ (\text{liquid})$$

the energy given up by the system to the surroundings is about 1×10^4 cal/mole.

Processes involving changes in translational, rotational, and vibrational energy in a molecule.—In the process of cooling gaseous oxygen from room temperature to near absolute zero,

$$O_2(\text{gas}, 300^\circ\text{K}) = O_2(\text{gas}, 0^\circ\text{K}),$$

the energy given up by the system to the surroundings is about 2×10^3 cal/mole.

Processes involving changes in mechanical potential energy.—When a mass of water is dropped from a height of 555 feet, the energy given up by the system to its surroundings is about 7 cal/mole.

Processes involving changes in mechanical kinetic energy.—In the stopping of a mass of water traveling with a speed of 50 miles per hour, the energy given up by the system to its surroundings is about 1 cal/mole.

In every process that occurs, every change in energy must be in accord with the first law of thermodynamics. This law governs not only the transfer of energy from one place to another, but also all the transformations of energy in its various forms.

The first law of thermodynamics was contained implicitly in the work of Carnot *(1)* in 1824 and of Mayer *(2)* in 1842, but was first stated unambiguously by Helmholz *(3)* in 1847. The first law may be summed up in the statement that the energy of the universe remains constant. That is to say, whenever any process occurs, the sum of all the changes in energy, taken over all the systems participating in the process, is zero.

Every system, if left to itself, changes rapidly or slowly in such a way as to approach a definite final state of rest or equilibrium *(4,5)*. Examples of processes tending toward such equilibrium are the following: The diffusion of solute material from a concentrated solution into a dilute solution, leading to uniform concentration; the passage of heat from a hot body to a cold body, leading to uniformity of temperature; the combustion of coal in air; the running down of a mechanical clock.

As these processes tend toward their final state of rest or equilibrium, the systems lose some measure of their capacity for spontaneous change. If we wish to harness one of these spontaneously occurring processes to do useful work, we would select one removed as far as possible from its state of rest or equilibrium, and which has a sufficiently high rate of change toward that equilibrium.

The passage of a system toward equilibrium does not necessarily mean that its energy is decreasing. That energy may be constant. What is being lost is the capacity of the system for spontaneous change.

This brings us to the idea that there exists a property of every thermodynamic system, caled its entropy, S, which is associated with its capacity for spontaneous change. The property is characterized by the fact that it is fully conserved over all systems for every reversible process, in which every driving force or pressure differs from the resisting force or pressure only by a differential amount, but increases for all other processes.

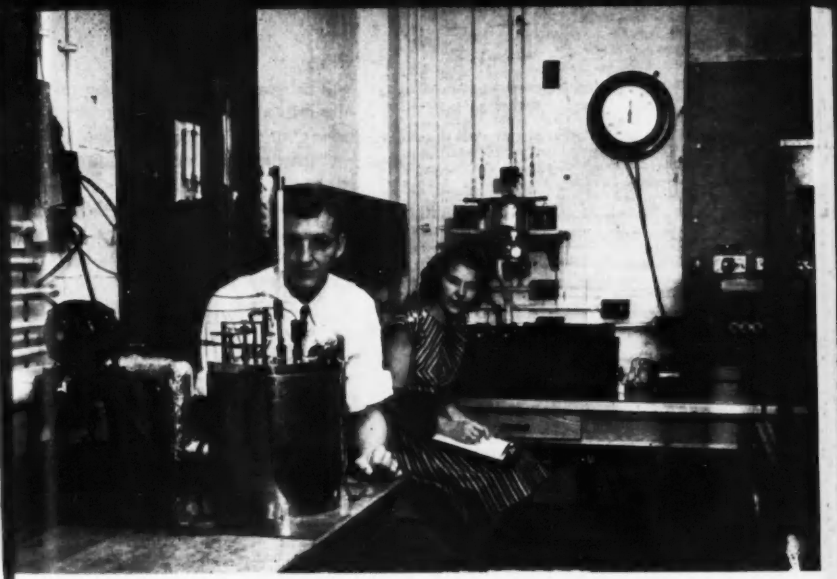
Whenever any process occurs, under any conditions, the sum of all the changes in entropy, taken over all the systems involved, is equal to or greater than zero.

When the given process is a reversible one, the sum of all the changes in entropy, taken over all the systems participating in the reversible process, is equal to zero.

In subjecting a given process to the scrutiny of the second law of thermodynamics it is usually convenient to specify or define a particular system, and to let all other possible systems constitute one large surrounding system. Whenever any reversible process occurs, the increase in the entropy of the given system is equal to the decrease in the entropy of the surroundings, and vice versa.

Greatest Entropy

For any reaction, the atoms constituting the molecules involved in the reaction will tend to go preferentially into those molecular configurations in which the entropy is greatest and in which the energy is lowest (algebraically). The greatest entropy is in general associated with those molecular configurations having the largest number of states of existence, that is, those molecular configurations in which the atoms will have the greatest freedom



▶ LABORATORY *at the National Bureau of Standards where Dr. Rossini's measurements of hydrocarbons are made, to determine what energies are involved in their combinations. The shiny round calorimeter in the foreground is used to measure heat involved in these reactions.*

of existence. On the other hand, the lowest energy is in general associated with those molecular configurations in which the atoms are bound most strongly, one to another, that is those molecular configurations in which the atoms will have the greatest structural security. The final state of equilibrium is a compromise between these two opposing tendencies, toward maximum freedom on the one hand and maximum security on the other.

In considering the possible production of a needed material of commerce by means of a number of proposed chemical reactions, one of the practical things to be known first about each reaction is the value of the equilibrium constant as a function of temperature. For many reactions it is not possible to determine the equilibrium constant directly, except at a prohibitive cost, and it becomes necessary to evaluate the equilibrium constant by means of the standard change in entropy, and the standard change in heat content, for each reaction.

The values of the standard change in entropy, for a given reaction may be obtained from the values of the entropies of each of the reactants and each of the products. The values of the entropies of the individual compounds may be determined by application of the third law of thermodynamics to measurements of heats

of transition, fusion, and vaporization, and heat capacities, down to low temperatures or by statistical calculations utilizing spectroscopic and other molecular data.

The values of the standard change in heat content, may be obtained from calorimetric measurements of the heats of appropriately selected chemical reactions.

From the values of the equilibrium constant as a function of temperature, the optimum temperature of operation for maximum yield is selected. The next point to be investigated is whether, at the selected temperature, the given reaction can be made to proceed at a sufficiently rapid rate for practical operation. Since the rate of reaction increases markedly with temperatures, those reactions to be operated at high temperatures will usually offer little difficulty regarding the rate of reaction, although considerable trouble from the occurrence of undesired side reactions may occur. However, if the reaction is to be run at a low temperature, it will usually be necessary to find for the given reaction a specific catalyst which will produce a sufficiently rapid rate without introducing a significant amount of undesired side reaction.

The ideal thermochemical table is one which will permit the calculation of the heat of every chemical reaction. Obviously it would be impractical to list in a table the heat of every reaction, but the same end is accomplished by listing for each chemical substance its heat of formation from the elements in selected standard states. It is evident that, by proper selection, the number of chemical reactions whose heats must be measured will be about the same as the number of substances listed in the table. Some saving in the number of reactions to be measured will occur among the organic compounds because of certain correlations which permit the evaluation of the heat of formation of higher members of homologous series, similar isomeric structures, etc.

Heat of Formation

The value of the heat of formation of a given substance may be the result of the determination of the heat of one reaction, as in the formation of liquid water from gaseous oxygen and hydrogen. For many other substances, however, the value will result from the measurement of the heats of several reactions. For example, the value of the heat of formation of methane, from its elements carbon and hydrogen, depends upon measurements of the heats of the following three reactions: the heat of combustion of gaseous methane in gaseous oxygen to form liquid water and gaseous carbon dioxide; the heat of combustion of solid carbon in gaseous oxygen to form gaseous carbon dioxide; and the heat of combustion of gaseous hydrogen in gaseous oxygen to form liquid water.

There will be certain basic values in the table which will be used very frequently in the derivation of other values. These basic values, which should be known with considerable accuracy, include the heats of formation of water, carbon dioxide, nitric acid, sulfuric acid, hydrogen chloride, hydrogen sulfide, and others. Because of this interdependence of many of the values of heats of formation, it is extremely desirable that values for

the important thermochemical constants be carefully selected, and when any change is made in any one of the basic values, corresponding changes should be made in all the values which depend upon it. It is for this same reason that the addition or subtraction of values of heats of formation from different thermochemical tables is a precarious undertaking.

In order to determine the value of the heat of formation of a substance, one selects for measurement reactions in which all the reactants and products, except the given substance, are either elements in their standard reference states or are substances whose heats of formation are known.

The chemical reactions whose heats are to be measured must be ones which proceed to completion (except in so far as a small amount of side reaction is known and can be corrected for) and for which the amount of reaction can be accurately measured.

The principle of the modern experimental method in thermochemistry is to carry out the reaction to be studied in the calorimeter in such a manner that it will be possible to compare the heat evolved by the chemical reaction with the heat evolved by electrical energy or with the heat evolved by a measured amount of a standard chemical reaction, the heat of which has already been compared with electrical energy.

(1) CARNOT, SADI. *Reflections sur la puissance motrice du feu.* Paris, 1824. (Translated in Harper's Scientific Memoirs, Sect. VI, New York 1899.)

(2) MAYER, J. R. Liebig's Ann. Chem. 42: 233. 1842.

(3) HELMBOLTZ, H. VON. *Ueber die Erhaltung der Kraft.* Berlin, 1847.

(4) LEWIS, G. N., and RANDALL, M. *Thermodynamics and the free energy of chemical substances.* New York, 1923.

(5) GIBBS, J. W. *Collected works* 1: New York, 1931.

On the Back Cover

➤ ENERGY *is the paramount consideration in designing a chemical plant, such as these absorbers at the Humble Oil Company's Texas installation. In these towers the liquid constituents are removed under high pressure from the gas. The oil employed is of such a character that it will not dissolve in the high pressure gas. Although handled at high pressures, the gas is returned to the reservoir with a minimum of pressure energy.*

Rheumatic Diseases Yield to Chemical From Adrenal Cortex

Seek New Sources of Cortisone

A GREAT STEP has been made in the treatment of the rheumatic diseases: arthritis, rheumatism, rheumatic fever, gout and other related diseases. A hormone from the adrenal cortex, a little but vital gland at the base of the brain, controls the symptoms of these ills that collectively are the most prevalent chronic diseases in this country.

The fountain of youth for aging people and a defense against more of the chronic diseases than arthritis may be found in cortisone and similar hormones so dramatically effective in making the rheumatically crippled get up and walk.

Dr. Edward C. Kendall of the Mayo Clinic who isolated this anti-arthritis hormone, tells how, after injections of small amounts of this material for a few days, a woman so crippled with rheumatism that she could not take more than two or three steps before the treatment went downtown and shopped for three hours. A man whose joints were so painful that he could not bear to have anyone touch him actually danced a jig. Obviously it is wonderful stuff and since the rheumatic diseases attack about seven and a half million people in this country there is a large potential demand for it. But, as it is very difficult to produce, little Cortisone is available.

Cortisone, (originally known as Compound E, which name was abandoned because of confusion with vitamin E) is a complex chemical that was originally obtained from the cortex of the adrenal gland. It is now being prepared synthetically from a bile acid. After its isolation by Dr. E. C. Kendall, Dr. Philip S. Hench of the Mayo Clinic headed the group that pioneered its clinical use. Merck and Co. chemists participated in the biochemical investigations that resulted in its partial synthesis. The full scientific name of Cortisone is 17-hydroxy-11-dehydrocorticosterone.

Relief of 7,000,000 arthritics and over 100,000 rheumatic fever patients in the USA is the obvious but distant goal for the new treatment but of deeper import is discovery that the substance that treats the patients so effectively actually seems to restore some of the tissues of the body that have been supposedly irreversibly changed by the inevitable process of aging. Cortisone seems to have a beneficial effect upon the metabolism of the collagens, the fibrous proteins that give support to the skin, tendons and bones.

In Mayo Clinic human experiments, much to the surprise of the investigators, old joints that were stiff were loosened up and the connective tissues were found to be physiologically renewed. This is the basis of renewed hope that a discovery even beyond the successful

treatment of the rheumatic diseases has been made.

Cortisone is also being tried, experimentally, in certain kinds of cancer. Obviously much more needs to be known about it before it can be used on patients generally. So those concerned with this hormone have turned to the National Academy of Sciences and a committee has been appointed to investigate this new medical development.

Scarce supplies of the dramatically effective drug will be allotted by the committee under the chairmanship of Dr. Chester S. Keefer of Boston, who during the war also was "czar" of civilian penicillin and streptomycin distribution.

The small amount of the new drug available during the remaining months of this year will be used for clinical and investigational purposes to provide information vitally needed to insure its safe and effective use.

The value of Cortisone in controlling the symptoms of this painfully crippling disease is regarded as established, Dr. A. N. Richards, Academy president, stated, but much remains to be learned concerning its possible untoward effects, its usefulness in other diseases and the mechanism of its action.

Some of the new drug will be used in diseases other than rheumatism experimentally if the investigators believe that the usefulness of the new treatment can be extended.

The Academy committee, which will use the facilities of the National Research Council for its work, consists of Dr. Keefer as chairman and Dr. Hans T. Clarke of the College of Physicians and Surgeons, New York, Dr. E. A. Doisy, St. Louis University School of Medicine, Dr. Robert F. Loeb of the College of Physicians and Surgeons, New York, Dr. C. N. H. Long, Yale University School of Medicine, Dr. E. K. Marshall, Jr., of the Johns Hopkins University School of Medicine, and Dr. Joseph T. Wearn of Lakeside Hospital, Cleveland, with Dr. David E. Price of the U. S. Public Health Service as liaison with that governmental agency.

For many years there have been a great many scientists who have studied the adrenal gland, its functions, its relations to other organs of the body. But the investigations were limited by the fact that there was never enough of the hormone available to study its effect in an adequate manner in man. With the isolation and partial synthesis of Cortisone and with the discovery that daily injections of this hormone will control the symptoms of rheumatoid arthritis, new frontiers of investigation have been opened. It should be possible to learn more concerning the usefulness of Cortisone in other diseases, its mechanism of action and its possible untoward effects.

One of the great difficulties at present is the short supply of Cortisone. It is exceedingly difficult to manufacture although every effort is being made to produce large amounts of material so that the greatest good can follow its use.

In this difficult period, when the supply is short, and information concerning the usefulness and dangers of Cortisone is lacking, the National Academy of Sciences Committee has

accepted the responsibility of allocating small amounts of Cortisone for the purpose of defining more definitely its usefulness and its dangers. With the small amount of Cortisone available it is impossible to carry on a therapeutic program. Activities must be restricted to research and investigation, that will yield the most scientific and the most useful information about Cortisone. This will include background problems as well as the study of specific diseases.

In planning their research program, the Committee of the National Academy of Sciences is utilizing to the fullest possible extent the resources of the National Research Council and the advice of experienced and competent investigators in the United States and Canada. Rheumatism and arthritis as well as other diseases for which relief may be anticipated will continue to be investigated, but more than that, aspects of physiology and pharmacology which are basic to fuller understanding of Cortisone will be studied.

The Committee will receive applications for Cortisone from institutions which have competent investigators who have had experience in the different fields under study. Due to the fact that the supply of material is so small, and the program is primarily one of research, the Committee cannot handle individual requests for Cortisone.

The outlook for an increased supply of Cortisone for 1950 is good. From the investigational program of the next five months, it is hoped that information will emerge that will be of the highest value in advising the medical profession how they can best use Cortisone for the alleviation of the greatest degree of suffering and the delay of deaths.

It is quite plain from present indications that the supply of Cortisone that will become commercially available within the next six months will be in no way equal to the specific demand. That is one of the most important and compelling reasons for defining more accurately the usefulness and dangers of Cortisone. How to get the greatest benefit to the largest number of people with available supplies of material is a most important consideration.

New Source Hunted

The supply of this hormone, produced by Merck and Co. in what is called the most complex and difficult chemical synthesis of commercial or medical value, is still extremely small. Only a score or two of patients, who have to be given the drug every day, have been treated. The drug is of course priceless, but it costs at last $20 a day to sustain a patient with 100 milligrams of Cortisone which is valued at $200 to $400 a gram. Next year production from ox bile (it takes 40 cattle to produce enough for one day's treatment) will supply about 2,000 to 2,500 patients.

That is the reason that there is an intensive search for new raw materials for synthesizing this adrenal cortical hormone. That is why the U. S. Public Health Service is asking $1,750,000 in emergency money to speed the medical research and investigation.

There is official excitement over the fact that a vine, growing of which is illegal in Africa, has seeds that under certain conditions contain a

substance, called 11-oxy-steroid, from which Cortisone can be made. This is true despite the fact that it may take years to explore, prove and cultivate the strophanthus plants whose seeds seem to substitute so conveniently for the bile of slaughtered cattle that is now the starting point of Cortisone synthesis.

In 1915 Drs. Walter A. Jacobs and Michael Heidelberger of the Rockefeller Institute in New York isolated from the seeds of strophanthus a chemical substance they called sarmentogenin. Cortisone's chemical ancestor, 20 steps closer to the final product than the bile acid starting point, was found to have the essential chemical structure duplicated in the African seed chemical. Here then is a chance to produce the final hormone from a plant that could be cultivated like other crops with a supply independent of the demand for meat and the amount of cattle slaughtered.

A strophanthus search is in progress. A Swiss group under Prof. Tadeus Reichstein of Basle was in the field first, because they were looking for a plant source for sex hormones that mean so much to the happiness of the human race. They found the desired plants and seeds in Africa. But there are complications for there are about 30 species of strophanthus and only one, Strophanthus sarmentosus, appears to produce the desired 11-oxy-steroid chemical grouping and then only under certain growing conditions and at certain times of seed growth.

A two-man expedition, Dr. John T. Baldwin of the U. S. Department of Agriculture and Dr. Erich Mosettig, of the U. S. Public Health Service, are in Basle beginning to track down strophanthus. First checking up the Swiss work, which has actually produced a smal amount of Cortisone from strophanthus, Dr. Baldwin will then collect plants, seeds and cuttings in the African area between Liberia and the Cameroons where the vine is supposed to grow best.

Natives are prohibited from raising the vine because they have used it in making an arrow poison and in making a brew with which charged criminals were tried—usually to die of the powerful heart-stimulating glucocides in the potion they were forced to drink (not the same chemicals used for the Cortisone raw material).

So Dr. Baldwin will be searching mountain tops and isolated areas for the illicit vines to be brought back to this country for the sake of medicine. Probably cultivation of the plant will be legalized under controlled conditions, just as poppies are raised for opium.

Some years ago Dr. David Fairchild, sent back from Africa some strophanthus plants. All of them flowered but only one bore seeds. These plants are being studied anew.

All plant and animal sources for steroid chemicals out of which Cortisone could be made are being sought. Chemists believe they can make the hormone out of mothballs and vinegar (naphthalene and acetic acid) but it would be a long and expensive process. They would rather start with something upon which nature has already done most of the synthesizing.

Government Program Assures Liquid Fuel to Avoid Future Shortage

Oil From Coal and Shale

➤ WHAT would happen if the United States suddenly ran short of oil! Most of us had a little foretaste of it during the war when gasoline and oil were mildly rationed. Cars stood in the garages, homes were chilly—if not cold, and transportation became a bit difficult all around. It is estimated that rationing saved only about a half million barrels of oil a day, compared to a total demand then of about four million barrels. This was not much, but it helped supply our armed forces and industry.

Research and development work, now in progress, promises to tap new domestic sources for gasoline, oil, and lubricants to avoid any future shortages. We can get our liquid fuels out of coal and oil shale if we need to. A great government development program is underway.

Dr. W. C. Schroeder, Chief of the Office of Synthetic Liquid Fuels in the United States Bureau of Mines, described this program as a guest of Science Service Adventures in Science program over the Columbia Broadcasting System.

In the absolute sense there is no danger of the United States running out of petroleum. However, our petroleum reserves cannot continue to provide indefinitely all the oil and gasoline we need. We must be prepared to use other raw materials as sources of liquid fuels.

Obviously, the daily oil production of the United States, now approximately 5 million barrels, will not vanish overnight. Too frequently, however, people obtain this idea when mention is made of today's enormous demands depleting our petroleum reserves. Apparently, the analogy drawn is that of a tank from which a full stream is taken until one hits bottom, stopping the flow abruptly. This is far from the truth when we speak of petroleum.

After reaching a peak, oil production declines gradually over a period of years. Petroleum first becomes increasingly difficult to find. Deeper drilling becomes necessary, costs increase, and the fields discovered tend to contain smaller amounts of oil. The United States appears to be in this stage now, for discovery costs for new oil have increased 500 percent over prewar days. This is one of the first economic warning flags.

Next, the prices of crude oil and products tend to rise over the long range. Short-term business conditions influence these prices, and they do not rise steadily but instead fluctuate up and down. Over a long period, however, the general trend is strongly upward. This country may be in or approaching this cycle now. Prices, in turn, affect demand. If high, they reduce demand to the point where temporary surpluses appear. If too high, they can restrict the use of oil to the point where it has an adverse effect on our economy. This reasoning assumes that 90 percent or more

of the oil we use is coming from domestic sources.

We now are importing oil. More and more oil is becoming available from foreign fields, and the United States is importing greater quantities. South America has relatively large oil reserves, but the Middle East is even more promising. Known reserves in the Persian Gulf area already are greater than those of the United States, even though fewer than a thousand wells have been drilled there as compared with more than a million in this country. The Middle East appears destined to become the oil center of the world.

Foreign oil can have a material effect on both the price and supply of oil in the United States. What we do about foreign oil happens to be a controversial question at this time. On one hand, importation can supplement and help conserve our own oil. On the other, it may discourage exploration and development in this country if it comes in at low cost and in large amounts. In the face of rising costs in the United States, this could become so serious that it would undermine our own industry — something we cannot permit. The uncertainty of foreign oil sources is a most serious disadvantage in time of emergency.

In 1948 about half the heat and energy used in the United States came from oil and gas and the other half from coal. Yet, with respect to reserves, oil and natural gas constitute only about 4 or 5 percent of this country's mineral fuel energy potential while coal amounts to 95 percent. It obviously is good judgment to shift a greater proportion of the demand burden to coal as rapidly as possible.

The government's synthetic liquid fuels research and development program is attempting to do just that. The new Coal to Oil Demonstration Plants at Louisiana, Mo. can produce a full range of liquid products from coal. First of their kind in this country, they can make aviation gasoline, motor gasoline, Diesel oil, heating oil, and fuel oil—all from coal. These products can be used in present-day motor cars, airplanes, tractors, oil burners, and all other such equipment without change or modification of the equipment itself. In addition, these plants will produce phenol, alcohol, and other valuable byproducts.

The capacity of the largest of the two is from 200 to 300 barrels daily, depending on the coal and catalyst used. A commercial-scale plant, as our engineers envision it, would produce a minimum of some 10,000 barrels daily.

Incorporating numerous innovations, these plants will demonstrate for private industry the respective merits of two basic processes for converting American coals to oil. First, the hydrogenation process, and second, the gas synthesis process. These two processes are complementary rather than competitive, and each is best adapted to produce different products. For example, the hydrogenation process excels in the production of high-octane aviation gasoline and heavy fuel oils, whereas the gas synthesis process is the better of the two if motor gasoline is desired. Each has its own use.

In these plants the Bureau of Mines

is fashioning a pattern of engineering and economic knowledge for the establishment of a new American industry based on the conversion of coal to oil. Synthetic liquid fuels from coal offered an assured supply adequate for centuries from known reserves within the United States—self sufficiency, in short, for whatever the future holds.

Gasoline, diesel and fuel oils, as well as other products from petroleum, can also be obtained from the nation's great deposits of oil shale that the government has prospected and worked experimentally. Refined products, such as gasoline, diesel and fuel oils, can be made from coal and oil shale for as little as 8.4 to 12 cents a gallon.

Excluding profit and interest on plant investment, gasoline can be produced from coal at costs ranging from nine to 12 cents per gallon. The cost of crude shale oil, again excluding interest on investment and profit, is approximately $2 per barrel, and the liquid fuels refined from this crude would cost about 8.4 cents per gallon.

Developments in mining and processing oil shale have been largely responsible for the low production cost of refined oil shale products. Mechanized mining has made high output possible. Progress in refining also has been substantial and from 75% to 85% of the crude shale oil now can be economically converted into gasoline, heating oil and diesel fuel.

Shortages of gasoline and fuel oil, common during World War II and the immediate post-war period, are no longer a problem. In spite of high-level consumption, the petroleum industry has raised production fast enough to overtake demand and even provide some excess of oil products.

In less than a decade, however, shortages of domestic petroleum can appear that would grow rapidly. There are four courses open to meet such shortages. They are the importation of oil, secondary recovery for present oil fields, development of tidelands oil and development of synthetic liquid fuels. Probably the most important of these is the development of synthetic liquid fuels. This would insure a supply independent of foreign sources and adequate for centuries.

New Chemical For Nasal Inhalers

➤ A NEW chemical compound has replaced benzedrine in nasal inhalers used to relieve colds, hay fever, and sinusitis.

Called Benzedrex, its discovery is credited to Dr. Glenn E. Ullyot, head chemist of Smith, Kline & French Laboratories. It has the advantage of being able to shrink the nasal membranes and thus relieve the congestion in the nose. At the same time it does not stimulate the user the way benzedrine does.

The search for this substitute chemical remedy grew from the reports of prisoners who removed the benzedrine-medicated paper from inside the containers to chew them or dunk them in beverages to get a "lift."

Milk Products

by Burton L. Hawk

➤ With this article, we shall make a comprehensive study of that remarkable liquid: milk. From our childhood we remember that milk was practically the most important thing that ever existed. It built strong bones, it made us grow, it helped to prevent disease and kept us healthy. The sad part of the story was that we hated the stuff! It could never compete with lemonade or Coca-Cola.

Nevertheless, chemically speaking as well as biologically, milk is a remarkable liquid. It can be considered as a solution, an emulsion, and colloidal suspension all in one. It is composed primarily of three parts:

1. Water. Approximately 87 per cent of milk is water.

2. Butterfat. The fat in milk varies, but is usually somewhere around 3½ per cent. It occurs in extremely tiny droplets which eventually come to the top of the liquid to form the familiar cream. When this substance is churned the droplets run together forming a solid mass which we know as butter. The fat in milk is composed of a mixture of the glycerides of the following fatty acids: butyric, caproic, caprylic, capric, lauric, mystristic, palmitic, stearic and oleic.

3. Solids Non-Fat. After the fat or cream is removed from milk, we have remaining a liquid (skim-milk) containing the so-called "Milk Solids Non-Fat." These are further divided into three groups:

(a) Proteins. The proteins of milk occur in colloidal suspension and include chiefly casein and albumin, or more technically, *lactalbumin*. Traces of other proteins such as lactoglobulin and fibrin are also found.

(b) Mineral Matter. When the residue of dried milk is burned, a white powder or "ash" remains. This ash represents the mineral content of the milk and is known to contain the following: potassium, sodium, calcium, magnesium, chlorine, sulfur and phosphorus. In addition, traces of iron, copper, zinc, aluminum, manganese, iodine, silicon, boron, titanium, vanadium, rubidium, lithium, and strontium have been found.

(c) Milk Sugar or Lactose. At last! This is the ingredient in which we are interested.

Properties of Lactose

Lactose is found only in milk. It has the same chemical formula as sucrose (cane sugar), $C_{12}H_{22}O_{11}$, but is different in molecular construction. It is not nearly so sweet as sucrose; nor is it fermented by yeast. It is a white, crystalline powder soluble in water and slightly soluble in alcohol. On hydrolysis, it forms glucose and galactose.

Preparation of Lactose

First, prepare some sour milk by adding a few drops of dilute acetic acid to 100 cc. of warm skim milk (milk from which cream has been removed). Allow to stand for 30 minutes to an hour. The milk will sepa-

rate into solid masses (curds) and a watery liquid (whey) — Little Miss Muffet's favorite dish.

Filter off the curds; neutralize the whey with calcium carbonate (precipitated chalk) and heat the neutral solution to boiling. At this point, the lactalbumin will separate out. Filter again to remove the albumin and excess calcium carbonate. The filtrate contains lactose and some mineral salts in solution. Heat until the solution is reduced by half. Then add an equal quantity of alcohol. Stir the liquid thoroughly and filter again. Finally place in an evaporating dish in a warm place. The lactose will crystallize out. Filter the crystals and wash with alcohol.

Detection of Lactose

Lactose reduces Fehling's Solution forming a yellowish-red precipitate of cuprous oxide. Fehling's Solution consists of two solutions—to be mixed immediately before using, as the mixed solution will deteriorate on standing. Solution A is prepared by dissolving 1.5 g. copper sulfate in 50 cc. water. Solution B is prepared by dissolving 8.5 g. sodium potassium tartrate (Rochelle salt) in 10 cc. warm water, adding a solution of 2.5 g. sodium hydroxide in 10 cc. water, and diluting with 30 cc. of water.

Or, you can use the more convenient Benedict's Solution which is only a single solution and does not deteriorate on standing. It is prepared by dissolving 10 g. of sodium citrate and 6 g. anhydrous sodium carbonate in 50 cc. of hot water. Add in small portions, stirring constantly, a solution of 1 g. copper sulfate in 10 cc. water. If the resultant solution is not perfectly clear, filter.

Dissolve a few crystals of lactose in 5 cc. of water. Add this to 10 cc. of Benedict's Solution or to 10 cc. of a mixed Fehling's Solution, consisting of equal parts Solution A and Solution B. Heat gently to boiling. If lactose is present, and we assume it is, the solution will gradually turn green, then yellow, and finally reddish brown.

Casein

With the memory of wartime food shortages still vivid in our minds, it is difficult to realize that less than a dozen years ago, America was suffering from the plague of *too much* food! Foremost of these problems was the surplus milk situation. Cows had to be milked and farmers had to sell the milk to profit; but, the amount of milk that could be consumed was limited. Too much milk! The farmer was unhappy because he was unable to make enough on his milk to cover the cost of feed. The creamery operator was unhappy because he had to operate at a loss; his employees were unhappy because they were underpaid.

What to do with all the milk? Too much was being produced for human consumption. There was only one answer. Find some other use for milk! Why coudn't it be used for industrial purposes as well as food?

Here the chemist entered the picture. It was well known to him that when milk sours, a heavy precipitate settles out. And he also knew that this precipitate consisted chiefly of a protein called casein. Berzelius first isolated it in 1812. In the manufacture of condensed whey for animal feed, the creamery operator considered casein a nuisance and the greatest problem was how to dispose of it.

Perhaps this protein could be used for something! The chemist went to work, and out of his test tubes, flasks and retorts came miraculous substances made from casein. What can it be used for? Let's investigate.

As an adhesive: Powdered casein is mixed with water glass (sodium silicate solution). A very strong cement is formed.

As a cement: Powdered casein is mixed with twice its bulk of slaked lime and finely powdered sand. Water is added to desired consistency. The result is a tough cement which will stand moderate heat. Another cement for glass can be made by dissolving powdered casein in a concentrated solution of borax.

As a paste: Casein is mixed with calcium tannate and made into paste with water.

As a plastic: The casein is treated with plasticizers, such as glycerol or tricresyl phosphate, under heat and pressure and the resultant mass hardened in formaldehyde. Many types of plastics are obtained with varied treatments of this sort and are used for buttons, fountain pens, lamp shades, combs, cutlery handles, billiard balls, electrical insulations, as a substitute for ivory and for celluloid.

As a paint: Casein paint leaves a coating that is washable, which gives it an advantage over other water paints. These paints contain casein and a pigment mixed with water.

As an artificial wool: Casein is dissolved in sodium hydroxide solution which is then forced through minute nozzles into a coagulating bath consisting of acidulated formaldehyde solution. This "wool" has been successfully used as a substitute for rabbit fur in fur-felt hats.

In addition casein is used for sizing paper, water-proofing, in the manufacture of leather, in horticultural sprays, and as a filler or binder in certain foods.

And this is only the beginning! More and more uses for casein are still being found. Indeed, there need be no further surplus of milk!

Preparation

Now that we know what we can do with casein, let's concentrate on obtaining it from milk.

It requires about one quart of skim milk to make one-half ounce of dry casein. The milk, from which all cream has been removed, is heated to 85°C. At this point dilute hydrochloric acid is added until precipitation ceases. The precipitate is separated either by filtration or decantation. Now it must be dried. This requires patience. The casein must not be heated too strongly, as it will be scorched. Stir frequently and use prolonged moderate heat. When dry, it is ground in a mortar.

Casein can also be precipitated by adding rennet to the milk. The curd can be removed with a spoon and heated as above.

* * *

Thus we have it again, the familiar story of the chemist converting the waste and surplus products into those of usefulness.

Your Bookshelf

Basic Chemical Reference Books

by JEANNE L. HOPSON

➤ TO BEGIN a chemical bookshelf or to enhance the value of one already started, here is a list of recent reference works.

➤ A GOOD, general reference book is M. Cannon Sneed's and J. Lewis Maynard's *General Inorganic Chemistry* (Van Nostrand, 1942, $5.25). Here is found both basic knowledge, covering the entire field, and an abundance of information on the elements and their compounds. It is well arranged and material can easily be found.

➤ FOR ORGANIC chemistry, Ray Q. Brewster's new book, *Organic Chemistry* (Prentice-Hall, 1949, $6.) is concise and yet gives a general all around picture.

➤ A SOMEWHAT more advanced text is *Organic Chemistry* by Lewis F. and Mary Feiser (Heath, 1944, $8.). Although the latest edition came out in 1944, it is still looked upon by most organic chemists as the standard book in its field. It stores a wealth of information which is well indexed.

➤ FRANK H. MACDOUGALL'S *Physical Chemistry* (Macmillan, 1943, $5.00.) is a useful work, especially in his approach to the laws of thermodynamics.

➤ FOR THOSE interested in analytical chemistry, there is an abundance of material from which to choose. *Quantitative Analysis* by W. C. Pierce and E. L. Haenisch (Wiley, 1948, 3rd ed., $3.75.) is a basic text yet includes some advanced theory. It stresses standard technics and common analytical procedures.

➤ LOUIS J. CURTMAN'S *Introduction to Semimicro Qualitative Analysis* (Macmillan, 1942, reprinted 1947, $3.75) is written primarily for a practical course in qualitative analysis. It correlates theory and practice in the new small-scale type of experiments.

➤ A BOOK that every chemist should have, or at least have access to, is *The Handbook of Physics and Chemistry* (Chemical Rubber Publishing Company, 1949, 31st ed., $6.) It compiles an immense amount of information. Especially valuable are the tables of data on inorganic and organic compounds.

➤ FRITZ FIEGEL'S new book, *Chemistry of Specific, Selective and Sensitive Reactions* (Academic Press, 1949, $13.50), is a handbook for analytical chemists. It also attempts to discover the regularities and rules that govern reactions. Translated by Ralph E. Oesper.

➤ NUCLEAR FISSION AND ATOMIC ENERGY (Science Press, 1949, $5.00), W. E. Stephens, Editor, collects and annotates the published literature on atomic energy. It is the result of a series of seminars on nuclear fission held in the Physics Department of the University of Pennsylvania in the fall of 1945.

Dark Lines in the Spectrum Furnish Key to Other Worlds

How Spectrum Lines Are Measured

➤ How THE white light of the sun is broken up into a band of bright colors when it passes through a prism was first studied by Isaac Newton at the beginning of the eighteenth century. He learned that each of the colors so separated is pure monochromatic light. It is not broken into more colors by passing through a second prism.

By the time Bunsen and Kirchhoff, in 1860, published the description of their spectroscope, scientists were familiar with the idea that color is a property of the wave-length of the light that shows it. When their instrument showed a spectrum made up of a series of bright lines of different colors, when it was trained on colored light from chemicals heated in the Bunsen burner flame, these physicists recognized the bright lines as images of the slit reproduced in several kinds of monochromatic light.

The ultimate puzzle was the source of these few distinct bands of pure light, each with its characteristic wave-length. The immediate problem was one of nomenclature. They needed a way to describe the spectra they saw. Fortunately, the means to do this had already been found.

Some forty years earlier, Joseph von Fraunhofer, a skilled maker of optical instruments, had been repeating Newton's experiment. He let a small shaft of sunlight shine through a hole in the window shutter, caught and spread it into a spectrum by means of a glass prism, and examined this spectrum with a small telescope. Here is his account of what he saw.

Dark Lines in the Spectrum

The Fraunhofer Lines

PRISMATIC AND DIFFRACTION SPECTRA, *Memoris by Joseph von Fraunhofer. Translated and edited by J. S. Ames, Ph. D. Harper & Brothers, New York and London, 1898.*

Determination of the Refractive and the Dispersive Power of Different Kinds of Glass, with Reference to the Perfecting of Achromatic Telescopes. Denkschriften der Königlichen Akademie der Wissenschaften zu München, V. 1817.

➤ IN THE window-shutter of a darkened room I made a narrow opening—about 15 seconds broad and 36 minutes high—and through this I allowed sunlight to fall on a prism of flint-glass which stood upon the theodolite described before. The theodolite was 24 feet from the window, and the angle of the prism was about 60°. The prism was so placed in front of the objective of the theodolite-telescope that the angle of incidence of the light was equal to the angle at which the beam emerged. I wished to see if in the color-image from sunlight there was a bright band similar to that observed in the color-image of lamplight.

But instead of this I saw with the telescope an almost countless number of strong and weak vertical lines, which are, however, darker than the rest of the color-image; some appeared to be almost perfectly black. If the prism was turned so as to increase the angle of incidence, these lines vanished; they disappear also if the angle of incidence is made smaller. For increased angle of incidence, however, these lines become visible again if the telescope is made shorter; while, for a smaller angle of incidence, the eye-piece must be drawn out considerably in order to make the lines reappear. If the eye-piece was so placed that the lines in the red portion of the color-image could be plainly seen, then, in order to see the lines in the violet portion, it must be pushed in slightly. If the opening through which the light entered was made broader, the fine lines ceased to be clearly seen, and vanished entirely if the opening was made 40 seconds wide. If the opening was made one minute wide, even the broad lines could not be seen plainly.

The distances apart of the lines, and all their relations to each other, remained unchanged, both when the width of the opening in the window-shutter was altered and when the distance of the theodolite from the opening was changed. The prism could be of any kind of refractive material, and its angle might be large or small; yet the lines remained always visible, and only in proportion to the size of the color-image did they become stronger or weaker, and therefore were observed more easily or with more difficulty.

The relations of these lines and streaks among themselves appeared to be the same with every refracting substance; so that, for instance, one particular band is found in every case only in the blue; another is found only in the red; and one can, therefore, at once recognize which line he is observing. These lines can be recognized also in the spectra formed by both the ordinary and extra-ordinary rays of Iceland spar. The strongest lines do not in any way mark the limits of the various colors; there is almost always the same color on both sides of a line, and the passage from one color into another cannot be noted.

With reference to these lines the color-image is as shown*. It is, however, impossible to show on this scale all the lines and their intensities. (The red end of the color-image is the neighborhood of A; the violet end is near I). It is, however, impossible to set a definite limit at either end, although it is easier at the red than at the violet. Direct sunlight, or sunlight reflected by a mirror seems to have its limits, on the one hand, somewhere between G and H; on the other, at B; yet with sunlight of great intensity the color-image becomes half again as long. In order, however, to see this great spreading-out of the spectrum, the light from the space between C and G must be prevented from entering the eye, because the impression which the light from the extremities of the color-image makes upon the eye is very weak, and is destroyed by the rest of the light.

* Fraunhofer's diagram, on which he lettered the regions showing the prominent dark lines, has been omitted here in favor of the Angstrom plates. Fraunhofer's letters have been retained by later spectroscopists to denote line groups, and are shown above Angstrom's drawings.

At A there is easily recognized a sharply defined line; yet this is not the limit of the red color, for it proceeds much beyond. At A there are heaped together many lines which form a band; B is sharply defined and is of noticeable thickness. In the space between B and C there can be counted nine very fine, sharply defined lines. The line C is of considerable strength, and, like B, is very black. In the space between C and D there can be counted 30 very fine lines; but these (with two exceptions), like those between B and C, can be plainly seen only with strong magnification or with prisms which have great dispersion; they are, moreover, very sharply defined. D consists of two strong lines which are separated by a bright line. Between D and E there can be counted some 84 lines of varying intensities. E itself consists of several lines, of which the one in the middle is somewhat stronger than the rest. Between E and B are about 24 lines. At B there are 3 very strong lines, two of which are separated by only a narrow bright line; they are among the strongest lines in the spectrum. In the space between B and F there can be counted about 52 lines; F is fairly strong. Between F and G there are about 185 lines of different strength. At G there are massed together many lines, among which several are distinguished by their intensity. In the space between G and H there are about 190 lines, whose intensities differ greatly. The two bands at H are most remarkable; they are almost exactly equal, and each consists of many lines; in the middle of each there is a strong line which is very black. From H to I the lines are equally numerous. In the space between B and H there can be counted, therefore, about 574 lines, of which only the strong ones appear on the drawing. The distances apart of the strongest lines were measured by the theodolite and transferred according to scale directly to the drawing; the weakest lines, however, were drawn in, without exact measurement, simply as they were seen in the color-image.

I have convinced myself by many experiments and by varying the methods that these lines and bands are due to the nature of sunlight, and do not arise from diffraction, illusion, etc. If the light from a lamp is allowed to pass through the same narrow opening in the window-shutter, none of these lines are observed, only the bright line R, which, however, comes exactly in the same place as the line D, so that the indices of refraction of the rays D and R are the same.

Light From the Stars

I applied this form of apparatus at night-time to observe Venus directly, *without making the light pass through a small opening;* and I discovered in the spectrum of this light the same lines as those which appear in sunlight. Since, however, the light from Venus is feeble in comparison with sunlight reflected from a mirror, the intensity of the violet and the extreme red rays is very weak; and on this account even the stronger lines in both these colors are recognized only with difficulty, but in the other colors they are very easily distinguished. I have seen the lines D, E, B, F perfectly defined, and have even recognized that B consists of two lines, one weak and one strong; but the fact

that the stronger one itself consists of two I could not verify owing to lack of light. For the same reason the other finer lines could not be distinguished satisfactorily. I have convinced myself by an approximate measurement of the arcs DE and EF that the light from Venus is in this respect of the same nature as sunlight.

With this same apparatus I made observations also on the light of some fixed stars of the first magnitude. Since, however, the light of these stars is much weaker than that of Venus, it is natural that the brightness of the spectrum should be much less. In spite of this I have seen with certainty in the spectrum of Sirius three broad bands which appear to have no connection with those of sunlight; one of these bands is in the green, two are in the blue. In the spectra of other fixed stars of the first magnitude one can recognize bands; yet these stars, with respect to these bands, seem to differ among themselves.

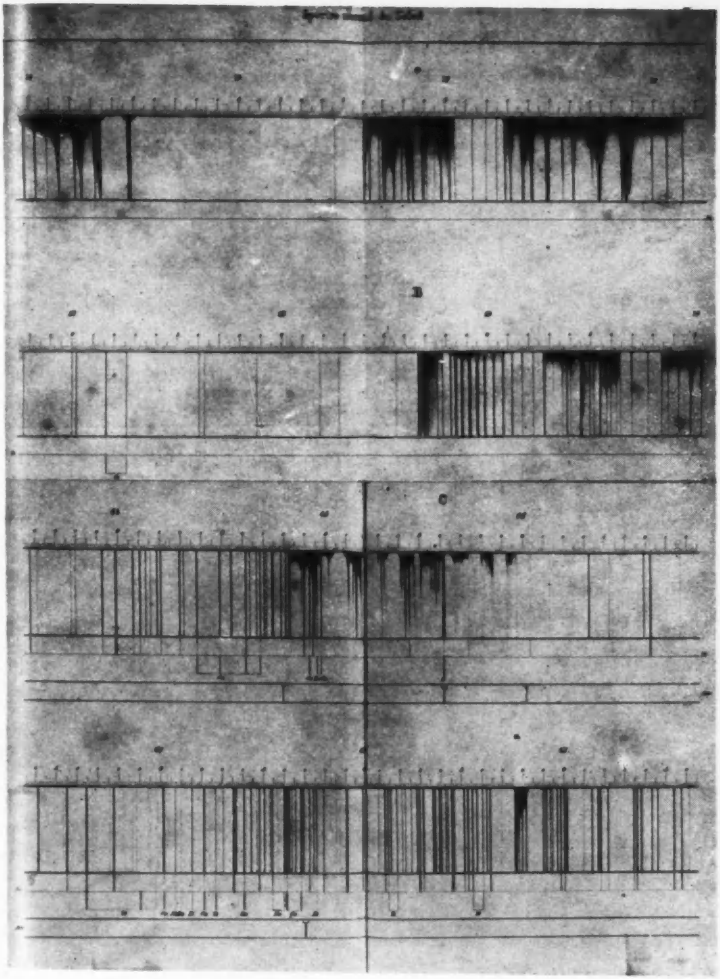
Since the objective of the telescope has an aperture of only 13 lines,[1] it is clear that these observations can be repeated with much greater accuracy. I intend to repeat them with suitable alterations, and with a larger objective, in order to induce, perhaps, some skilled investigator to continue the experiments. Such a continuation is all the more to be desired, because the experiments would serve at the same time for the accurate comparison of the refracted light of the fixed stars with that of sunlight.

The light of electricity is, with respect to these lines and bands, markedly different from sunlight, and also from the light of flames. Several lines are found in the spectrum of this light; some are very bright, and among these one in the green is almost dazzingly bright in comparison with the rest of the spectrum. There is another line in the orange which is not quite so bright; it appears to have the same color as the bright line in the spectrum of lamplight. If, however, the angle of refraction is measured, it is found that its light is refracted much more—about as much as the yellow rays of lamplight. Near the red end of the spectrum there is a line which is not very bright; its light is refracted, so far as I could be sure, exactly the same as that of the bright line of lamplight. In the rest of the spectrum four other lines can be recognized easily.[2]

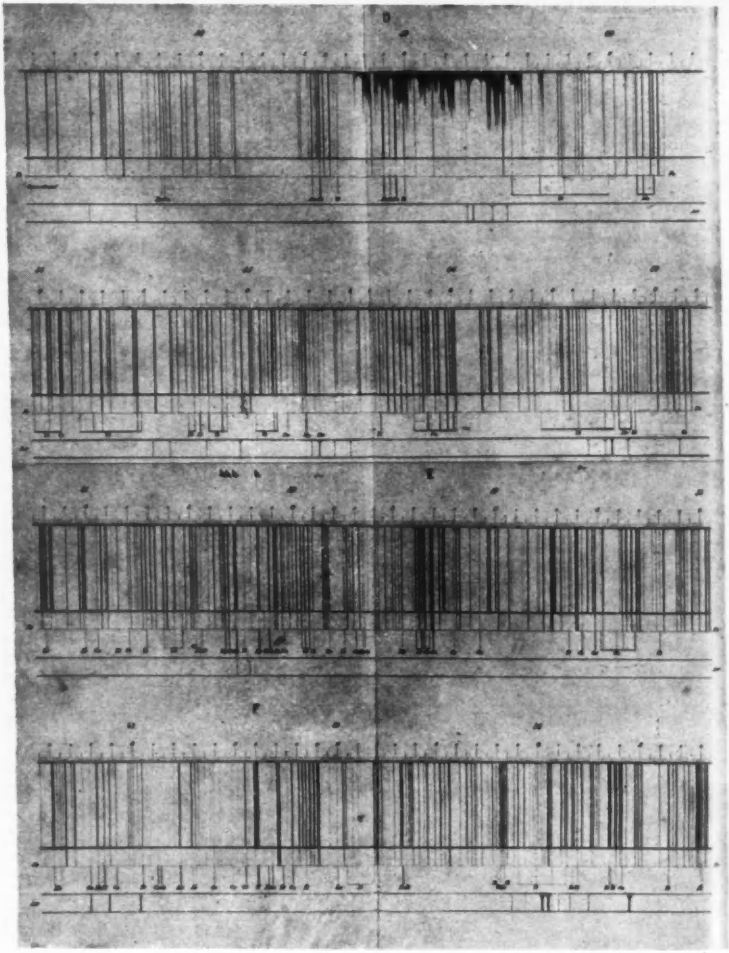
If lamplight is allowed to pass through a very narrow opening of 15 to 30 seconds' width and then to fall upon a strongly dispersive prism placed in front of a telescope, it is seen that the reddish-yellow bright line of this spectrum consists of two very fine bright lines which in intensity and distance apart are like the two dark lines D. But, regardless of the width of the slit, if the point of the flame and the lower blue end are covered, and so only the brightest portion of the flame exposed, the reddish-yellow lines of the spectrum appear less bright, and therefore are recognized with more difficulty. These lines, consequently, seem to be

[1] (1 centimeter equals 4.43296 lines.)

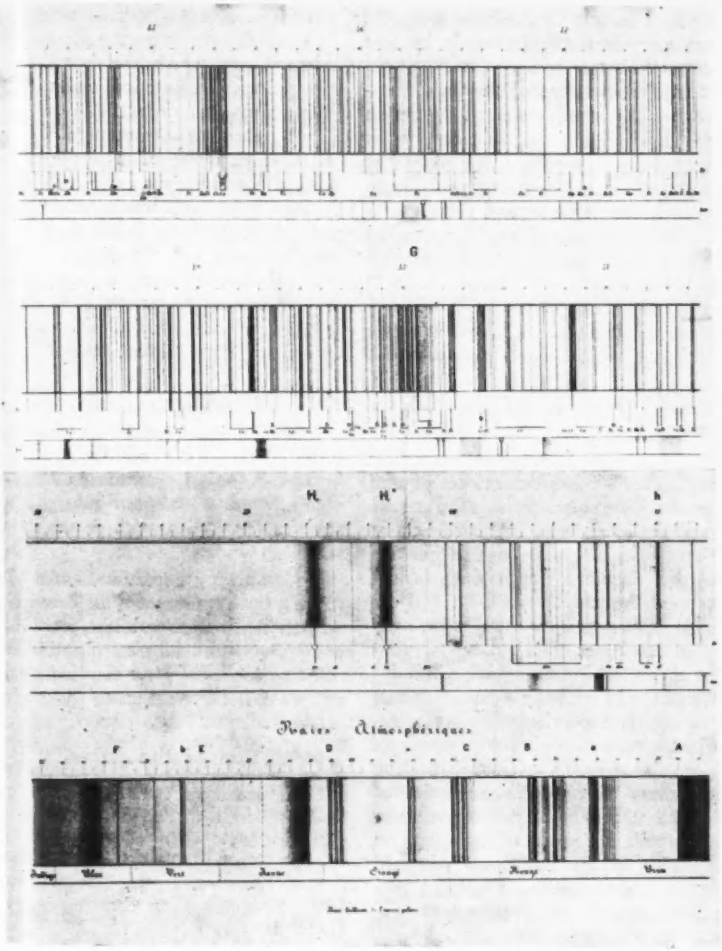
[2] In order to use the electric light I placed two conductors one-half an inch apart, one being joined to an electrical machine, the other to the earth, and connected them with a fine glass fibre. The light then appeared to pass continuously over the fibre, and the latter formed a fine luminous line.



▶ ANGSTROM *described his plates (the original six here combined into three) in the following words: "In order that the micrometric measures, described in the preceding pages, might be more accessible and that the reader could more easily find in the solar spectrum the Fraunhofer lines measured by me, I*



have constructed an Atlas bearing the title Normal Spectrum of the Sun, which accompanies this memoir. This Atlas contains six tables, in which have been drawn, with the greatest possible care, the spectrum lines from a to H. Mr. Thalén, who has very kindly helped me in this work, has made the drawings after the wave-lengths furnished by me; moreover, he has sought, as far as



possible, to indicate the relative intensity of the different rays. The upper edge of each part of the spectrum drawn is furnished with a millimeter scale permitting measurement of the wave-length of the individual lines of the spectrum to about one hundred-millionth of a millimeter." Ångström's method of fitting the lines of the spectrum to the millimeter scale has continued standard.

formed mainly by the light from the ends of the flame, especially by that from the lower one.

In the spectrum of the light caused by the combustion of hydrogen and alcohol, the reddish-green line is very bright in comparison with the other portions. When sulphur is burned it is seen with great difficulty.

I intend to repeat these experiments which have reference to the perfecting of achromatic telescopes, using a new instrument by means of which I hope to obtain at least twice the accuracy. I shall be able also to make new experiments with this instrument for which my present one is not adapted, and which will be of interest perhaps for practical optics.

In all my experiments I could, owing to lack of time, pay attention only to those matters which appeared to have a bearing upon practical optics. I could either not touch other questions, or at most not follow them very far. Since the path thus traced in optical experiments seems to promise to lead to interesting results, it is greatly to be desired that skilled investigators should devote attention to it.

Measurement of the Lines

Wave-Lengths of the Lines

➤ THE MODERN reader can recognize in Fraunhofer's descriptions of the double line at D the widespread presence of sodium, and can see that Fraunhofer himself had begun to suspect that the bright lines of the lamp flame and the dark lines of the solar spectrum were in some way identical. After the discoveries quoted above, their author improved his apparatus by substituting a diffraction grating for the prism, and got a series of spectra of higher orders.

By the aid of a diffraction grating apparatus, Prof. A. J. Ångström of Upsala, Sweden, a generation later undertook the task of carrying on spectrum studies that Fraunhofer had left to his successors. Ångström provided the scale of measurement that was needed for locating spectral lines, and defined those lines in terms of their positions and wave-lengths. His Atlas of spectrum lines is here reproduced. The subdivision of the metric system in which light waves are measured is called by his name.

In 1853, Ångström formulated the secret of the Fraunhofer lines as follows: "A gas in the state of incandescence emits luminous rays of the same refrangibility as those which it is able to absorb."

The following quotation from Ångström's book (composed in Swedish, written in French, published in Germany!) tells how he plotted and identified a number of spectrum lines, and applied this information to the study of the sun.

Description of the Atlas

RECHARCHES SUR LE SPECTRE SOLAIRE *par A. J. Ångström, Professeur de Physique à l'Université d'Upsal. Spectre Normal du Soleil. Atlas de Six Planches. Upsal,* 1868, *Berlin* 1869. *Translated for* CHEMISTRY *by Helen M. Davis.*

➤ SO THAT the micrometric measurements, described in the preceding pages, might be more accessible and that the reader could find easily in the solar spectrum the Fraunhofer lines that I have measured, I have

constructed an *Atlas* bearing the title: *Normal spectrum of the sun,* which accompanies this Memoir. This Atlas contains six plates, on which have been drawn, with the greatest possible care, the spectral lines from *a* through *H*. Mr. Thalén, who has been kind enough to assist me in this work, has made the drawings after the wave-lengths I have given him; moreover, he has tried, as far as possible, to indicate the relative intensity of the different lines.

The upper margin of that part of the spectrum portrayed is furnished with a millimeter scale allowing measurement of the wave-length of individual rays of the spectrum to nearly one hundred-millionth of a millimeter. Since one division of the scale corresponds to one ten-millionth of a millimeter of wave-length, this scale will give us immediately, if we omit the three zeros which follow the decimal point, the first four decimal figures, and we can get, besides the fifth figure by estimation of tenths of a millimeter. Our diagrams thus enjoy almost the same accuracy as the measurements themselves. To be strictly truthful, some errors, amounting to a tenth and sometimes to two tenths of a millimeter, have slipped into the engraving, but the measurements themselves of weak lines being doubtful in the order of that amount, it is believed that these errors are practically insignificant.

To guide the engraver in respect to the relative intensity of the lines, I have numbered them from one to nine, with the exception of the strongest lines, such as *C, D, F,* b_1 and some others. These determinations, necessarily approximate, are based principally as far as that part of spectrum situated between *a* and *F* is concerned, upon direct measurements, but for that part remaining between *F* and *H*, they follow the drawings of Messrs. Hoffmann and Thalén.

All the lines shown on my plates between *C* and *b*, have been measured directly; their number is a little greater on my plates than those given on the corresponding plates of Mr. Kirchhoff. Toward the violet end of the spectrum, the observed lines are, on the other hand, less numerous, owing to the weak dispersion in this region. Nevertheless, to give this portion of the spectrum as perfect a correspondence with nature as possible, I was obliged to put in here some lines whose wave-length I have not been able to measure directly. However, I have tried to introduce as completely as possible into my plates all the known lines of substances which, by means of spectral analysis, have been proved to have real existence in the atmosphere of the sun. I shall add finally that certain lines have been drawn as being double, conforming to their appearance in the refraction spectrum, although in that of diffraction, it is not possible to recognize them in that form. This is the case, for example, with the double lines to be found to the right of the line B.

I have shown also upon the plates the origin of each line and its correspondence with the lines of metallic spectra, because these facts have been determined by researches that we have made, Mr. Thalén and I, whether together or each on his own account. In this connection, I ought to state that all the researches on *titanium* and its existence in the atmosphere of the sun

are due exclusively to Mr. Thalén, who has written in the preface to his Memoir, cited above, upon the wavelengths of the metallic spectra.

It goes without saying that I have profited also by the plates of spectra published several years ago by Messrs. Kirchoff and Hoffmann.

Finally, to make known the number of lines indicated on my plates as derived from known substances, I have summed them up in the following table:

Substances	*Number of lines*
Hydrogen	4
Sodium	9
Barium	11
Calcium	75
Magnesium	4+(3?)
Aluminium	2(?)
Iron	450
Manganese	57
Chromium	18
Cobalt	19
Nickel	33
Zinc	2(?)
Copper	7
Titanium	118*

* The number of lines of titanium entered on my plates is many less than that given by Mr. Thalén, whose count reaches 200. The reason for this is: 1st, that my plate E-F was already engraved before he had finished his researches on this metal, and: 2nd, that many of the lines of the solar spectrum which actually correspond to the titanium lines are so weak that they can only be distinguished in exceptional cases of purity and of dispersion of the solar spectrum.

The total number of these lines comes to about 800, which number could easily be increased considerably by using apparatus of greater energy to bring the substances to the state of incandescence[3]. Nevertheless, the number already found is sufficient, it appears, to explain the origin of nearly all the strong lines of the solar spectrum and thus confirms the opinion, which I stated in a former work, that the substances actually making up the mass of the sun are without doubt the same as those of the earth. We must not, however, forget to state that there actually exist between *F* and *G*, about in the middle, some strong lines whose origin is unknown to me; but, the conclusions which might be drawn in favor of solar substances unknown on our globe, would certainly be premature. Nevertheless, we note a curious fact, that the strongest of the unknown lines coincides with a strong line of bromine; but the lines of chlorine having no correspondence with the Fraunhofer lines, it is not probable that this coincidence occurs on account of bromine.

Aluminium possesses certain brilliant lines in many parts of the spectrum, but the lines situated between the two at *H* are the only ones which seem to coincide with Fraunhofer lines. To explain this singular phenomenon, it is necessary to say that the violet lines appear as the strongest in the spectrum of this metal. Like the yellow lines of sodium, these two lines of aluminium sometimes show absorption phenomena in that a black line appears in the middle of each of them, which proves the great intensity of the said line. In observing the ultra-violet lines of this metal, it ought to be determined whether the two lines mentioned above coincide or not with Fraunhofer lines; for if my supposition is true, the ultra-violet

[3] This is only in working with iron, manganese and calcium, which require a voltaic pile of 50 couples.

lines ought also to coincide with dark lines in the solar spectrum.

To two lines of zinc which I have shown on my plates as coincident with Fraunhofer lines, it is necessary to add a third, situated at 4809.7; but, in respect to two lines, very large and very strong, of a nebulous appearance, no correspondence is visible; hence, the presence of zinc in the sun seems to me very doubtful. I will say, however, that there are three lines of magnesium, of the same nebulous appearance, which have no more correspondence with Fraunhofer lines, yet the presence of that substance in the sun allows not the least doubt.

Among all the substances, *iron* surely produces the greatest number of lines in the solar spectrum, showing two maxima, of which one occurs near *E*, and the other near *G*. Some appear to be common to those of calcium, but such a coincidence of lines of different metals is only apparent. To give an example, I shall mention the strong line of iron between *E* and *b*, whose wave-length is 5226, and which has been drawn as a simple line on Mr. Kirchhoff's plates and on mine. Nevertheless, as Mr. Thalén proved by strongly increasing the dispersion by using six prisms of flint glass, of 60°, that line is actually *triple*, and the lines which make it up, when separated are one from iron and one of the others from titanium.

Among the metalloids, *hydrogen* is the only one which spectral analysis has been able to show as belonging to the sun, so that the other substances, such as oxygen, nitrogen and carbon, which exist in such great quantities on the earth, have never been able to be discovered in the sun by this means. To show clearly the impossibility of spectrum analysis for oxygen and nitrogen, I have marked below the solar spectrum the principal lines of the electric spectrum of the air, and it will be seen from this that there are no coincidences between the lines of the two spectra.[4]

In spite of the almost complete lack of coincidences between the lines of the solar spectrum, on the one hand, and those of oxygen and nitrogen, on the other, it cannot be correct to pronounce definitely upon the total absence of these two substances in the sun. Here is the reason: the spectrum of the air can be produced only between the carbon electrodes of a voltaic pile of 50 couples, and in general it does not appear if the electricity propagates itself, so to speak, electrolytically. The spectrum necessarily appears with the appearance of a disruptive discharge, as we evidently prove in experiments with the Geisler tube, containing these two gaseous substances.

In fact, in so far as the discharge is accompanied by electrolysis, the spectra obtained from rarified air approach those of the substances composing it, and therefore it is quite improper to call them, with Plücker, spectra of the first order; on the contrary, by using the condenser, the discharge immediately becomes disruptive and we get, at the same time, the

[4] There is a further practical and very useful application which can be made of this spectrum of the air. In the same way that the wave-lengths of the metallic lines can be determined by registering them in the normal spectrum, it is possible to reach the same result by aid of the spectrum of the air, although certainly with less accuracy in the latter case. For this purpose it is only necessary to know the wave-lengths comprising this last spectrum, which the plates above mentioned give with sufficient accuracy.

spectra of the elementary bodies, that is to say, the ordinary spectrum of air. This fact, very important indeed in the true interpretation of the spectra of the sun and the stars[5], shows us that it is very probable that the high temperature of the sun is not sufficient to produce the bright lines of oxygen and nitrogen, and consequently even supposing that these substances exist in the sun, they would not give rise to dark lines in the solar spectrum, just as the actual existence of these substances in the terrestrial atmosphere does not give rise to them as telluric lines.

The observations on total eclipses of the sun, and in particular those which have recently been made by Messrs. Janssen and Rayet, have proved two facts: 1st that the luminous surface of that star is immediately surrounded by heavy gas which, constituting the so-called protuberances, gives rise to a spectrum of brilliant lines; 2nd that this is surrounded on the outside, at a considerable height, by the corona whose light, polarized and giving a continuous spectrum, comprises the photosphere of the sun itself. This being admitted, and supposing that this corona contains the terrestrial elements, it seems to me that we cannot do otherwise than admit nitrogen, oxygen and hydrogen with the others.

* * *

This is the second of a series of articles describing the data we get directly from the atom. In the September issue of CHEMISTRY, *Bunsen and Kirchhoff's description of their spectroscope gave the key to atomic messages. These are revealed in the bright-line spectra characteristic of the chemical elements. If you have built a spectroscope, you can photograph the spectrum of reflected sunlight and identify the Fraunhofer lines and the elements to which some of the lines correspond, using Ångström's plates. They are reproduced here on a reduced scale, but the measurements are marked. Direct messages thus reveal the constitution of the sun, and open the way to chemical analysis of the farthest galaxies of stars. As the next step in this series, it will be shown how these atomic vibrations bring data about the minute and hidden region from which they come.*

[5] After the memorable discovery by Mr. Huggins, that one of the three bright lines found in the spectra of the nebulae coincides with the strong greenish line of nitrogen. But this line is double, and the distance of the two components is three units of ten-millionths of a millimeter; it seems therefore that it ought to be possible to confirm this same doubling in the corresponding line of the nebular spectrum.

New Nitrogen Isotope Discovered

► DISCOVERY of a new kind of nitrogen, one of the commonest of the chemical elements, has been made by Dr. Luis W. Alvarez of the University of California's Radiation Laboratory.

It is mass 12, contrasted with mass 14 nitrogen which exists in greatest abundance in the air we breathe. The new isotope is manufactured by bombarding carbon with high energy protons from an atom-smashing linear accelerator. The new nitrogen 12 lives only a fleeting instant, a mere dozen thousands of a second of half-life, before disintegrating.

Novel Use of Magnetism Applied in New Patent

Gold by Magnetic Separation

▸ GOLD AND SILVER can be pulled out of hitherto unworkable low-grade ores by means of invisible iron handles, in a process on which U. S. patent 2,479,930 has been granted to Earl C. Herkenhoff and Norman Hedley of Stamford, Conn., assignors to the American Cyanamid Company.

Concentration of practically all precious metals out of their ores begins with getting them into a cyanide solution. This is followed, in the case of high-grade ores, with precipitation on finely divided zinc. With some low-grade ores, finely divided activated carbon is used instead, followed in turn by a flotation treatment. Flotation is troublesome, however, and appreciable losses are entailed.

Messrs. Herkenhoff and Hedley obviate this handicap by rendering their carbon magnetic, either through the incorporation of ground magnetite or by impregnation with an iron salt which is subsequently reduced, leaving pure iron in the pores. After the carbon has absorbed the dissolved gold, it is separated out by familiar commercial magnetic means. Much larger carbon particles can be used, with corresponding reductions in losses.

The inventors describe their method in the following account.

This invention relates to an improved process for recovering precious metals by cyanidation, and more particularly to the treatment of very slimy gold ores.

Cyanidation is one of the most important ore dressing methods used in the recovery of precious metals, such as gold and silver, from ores containing them. In the ordinary cyanidation process the finely divided ore is treated with a solution of cyanide, such as sodium or calcium cyanide, in the presence of lime and oxygen to dissolve the precious metals in the form of their soluble double cyanides. The solution thus obtained, which is known as the pregnant solution, is then filtered from the ore pulp and the precious metals precipitated by the use of finely divided zinc, followed by a second filtration. The zinc precipitation method has been developed to a very high state of metallurgical efficiency. In fact, it is so efficient that it will precipitate almost 100% of the dissolved precious metal cyanides.

The standard cyanidation process using zinc as a precipitant requires as an essential step a filtration or continuous counter-current decantation washing of the pregnant solution from the ore pulp. These steps constitute limiting factors on the type of ore. Low grade precious metal ores which may contain extremely small amounts of gold must be treated economically or the precious metal values will not repay the cost of treatment. Therefore, low-grade slimy ores, such as for example, the so-called saprolites,

have not been considered hitherto economically treatable by the ordinary cyanidation procedure using zinc precipitation, because the sticky slimes of these ores impose such a load on the filters that the filtration step cannot be carried out economically. Theoretically the continuous counter-current decantation method of treatment may be applied to slimy ores but ordinarily it requires a very high capital outlay for many units of equipment, and even then must sometimes be followed by some method of filtering in order to recover gold in solution.

Various attempts have been made to render the low grade precious metal ores amenable to cyanidation. Of these attempts, the only one which has been at all successful uses activated carbon as a precipitant and then removes the activated carbon from the ore pulp with the precipitated precious metal values in the pores of the carbon. The carbon can be used for precipitation without first filtering the ore pulp to produce a clear solution, which is required in the zinc process. However, the activated carbon precipitation process, while it has opened up some types of ore to cyanidation which were hitherto untreatable by the zinc precipitation process, is by no means ideal and has serious drawbacks. These drawbacks arise largely from the method which has hitherto been used in removing the precious metal bearing carbon from the ore pulp. The process employed involves froth flotation in the presence of a collector for carbon, such as hydrocarbon oils. It is possible to obtain a reasonably high recovery of precious metal by this method, but usually at a very serious sacrifice in grade of the flotation concentrate due to contamination with readily-floatable gangue slime and, in some cases, with barren sulfides. It should be remembered that this flotation concentrate must then be dewatered, which is made difficult by the high slime content, and then processed, usually by pyrometallurgical methods, in order to recover the precious metals. A fairly high grade of concentrate is necessary in order to keep costs and losses down. Unfortunately, the carbon precipitation process followed by flotation results in a low grade of concentrate and quite often the recovery of the loaded carbon is not complete, resulting in residue losses. Another serious drawback lies in the fact that flotation requires a small size of carbon particle. As a result, the concentrate contains relatively finely divided carbon which, in pyrometallurgical processes, increases the mechanical dust loss when the carbon is smelted. Still another objection is that the collectors employed for flotation of the carbon tend greatly to reduce the activity of the carbon and make it unfit for further precipitation if cycling or counter-current flow of the carbon is employed.

In spite of the above drawbacks cyanidation processes using activated carbon as the precipitant represent an important advance in the treatment of certain precious metal ores or fractions thereof. They are, however, compromises, leaving much to be desired, and of course the drawbacks of the process, which are reflected in higher costs, correspondingly restrict the field of applicability of the process. Certain slimy low-grade ores cannot be eco-

nomically treated even with ordinary activated carbon precipitation methods.

The present invention constitutes an improvement in the activated carbon precipitation process which removes the major drawbacks, permitting metallurgy which, under favorable circumstances, is substantially as good as that obtained by zinc precipitation, and at the same time recovers a high grade product which can be effectively treated by ordinary metallurgical processes without excessive loss. Essentially, the present invention employs activated carbon in which sufficient magnetic material, such as finely divided iron, ferroalloys, magnetite, or the like has been incorporated so that the carbon particles are sufficiently magnetic to permit recovery on ordinary magnetic separators.

The process of the present invention has many advantages over the known activated carbon precipitating processes in which recovery was effected by froth flotation. In the first place, the ratio of concentration is much higher, often producing 3¼ times as high a grade. Secondly, magnetic separation is one of the most positive, rapid and cheap recovery procedures, using contact equipment, and requiring a minimum of labor and power cost, and the treatment does not affect the activity of the carbon. A further advantage of the process of the present invention lies in the fact that it is not necessary to use such finely divided carbon. Magnetic separation is just as effective on large carbon particles as on those of flotation size. This introduces a further economy, since it is not necessary to crush and size the carbon carefully and dust losses from excessive amounts of fines are eliminated or greatly reduced. At the same time the use of larger carbon particles has been found to involve no corresponding decrease in efficiency of precipitation. Still another advantage is that the density of the carbon particles is increased and this tends to eliminate possible short circuiting of the carbon at the surface of the pulp and allows better mixing with the pulp.

The magnetic activated carbon of the present invention may be prepared by various means. For example, the activated carbon may be prepared and then treated with a finely divided magnetic solid such as fine magnetite, for example, magnetic concentrates, using a suitable binder to cause the magnetic particles to adhere to the carbon particles. Any binder which is not affected by the cyanidation procedure and does not interfere with precipitation may be used, and the present invention is in no sense limited to the use of any particular binder. Sodium silicate, however, is preferred, as it is one of the most effective binders, and at the same time very cheap. After the magnetic material has been incorporated in the activated carbon the product is normally dried at a temperature not greatly exceeding the boiling point of water, and reactivated by heating to the customary high temperature for a short period of time.

Another method of incorporating magnetic particles in the carbon is to impregnate the carbon with a solution of an iron salt, which is then treated with a reducing agent in order to reduce the salt to metallic iron.

A third method is to produce mag-

netic iron oxide in the carbon by decomposing an absorbed solution of a suitable iron salt with heat.

It is an advantage of the present invention that the process steps are quite flexible. Thus, for example, the magnetic carbon may be added either during the dissolution of the precious metals by the cyanide solution and after solution is complete. It is also possible to add the carbon in stages or to effect a counter-current flow, that is to say, the fresh carbon being added to the weakest part of the solution. This flexibility of procedure makes it possible to fit the improvements of the present invention into existing flowsheets or to adapt flowsheets to local conditions.

A magnetic recovery of the activated carbon containing the precipitated precious metals follows in general standard magnetic recovery procedures, and the common types of magnetic separators may be employed without any material change. The possibility of using standard equipment reduces materially the cost of this portion of the process.

The concentrate itself is of granular character and is very readily filtered or de-watered. This is a great advantage over the recovery of carbon by froth flotation. It may then be shipped directly to smelters or it may be burned and the small volume of residue cyanided or otherwise treated by known methods for handling such concentrates. The presence of the small amount of magnetic material does not interfere in any way with the recovery of precious metals from the concentrate.

Some low grade precious metal ores contain small amounts of magnetite or similar magnetic materials. These, of course, would be removed with the magnetic carbon concentrate and would result in reduction of grade of the latter. It is therefore desirable when an ore has any considerable content of magnetic material, to subject it to a preliminary magnetic separation to remove such material. The tailing from this preliminary magnetic separator is then treated by the process of the present invention, exactly as is the case with non-magnetic ore.

The invention will be described in greater detail in conjunction with the following specific examples. Although in most of the examples technical grade of black calcium cyanide was used in accordance with standard cyanidation practice, the reagent consumptions are expressed as sodium cyanide equivalents.

The present invention is of primary importance in the beneficiation of slimy precious metal ores. The process, of course, works perfectly with ores which are not slimy and which are susceptible to the ordinary cyanidation procedures. In some cases the present invention is of great economic importance even with ores which can be handled technically by other cyanidation procedure. The capital investment of a plant in which the process of the present invention is used is very much smaller than a conventional cyanidation plant with its large filters or decantation tanks. Therefore, when small ore bodies, such as old tailings, piles, and the like are to be treated, the reduced capital expenditure makes the present process economically feasible where the ordinary cyanidation procedures with

their large capital investment could not be used economically. In a broader aspect, therefore, the present invention may be used with ores which can be treated effectively by other cyanidation processes. The preferred modification, however, in which slimy ores are treated constitutes by far the most important practical field of utilization.

New Patents With Chemical Angles

Boron Extraction

▶ ELEMENTAL BORON, useful in regulating the operation of atomic piles, can be obtained in purer form, it is claimed, by a process on which Dr. Frank J. Sowa of Cranford, N.J., has taken out patent 2,465,989. First, metallic sodium is dissolved in liquid ammonia, then potassium fluoborate is added and the ammonia evaporated off. The mixture is covered with common salt until fusion is completed; then the mass is finely ground and treated successively with hot water, hydrochloric acid and ammonium bifluoride. The product is described as elemental boron of 70% purity.

To Stir Covered Beaker

▶ HOW TO STIR the contents of a glass or a laboratory beaker when covered by a lid is no problem to Harry H. Neal of Los Angeles, recipient of patent 2,466,468. He simply drops in a short bar magnet, which may be suitably coated to resist corrosion, then sets the covered vessel on a base beneath which another magnet is spun rapidly by a motor.

Synthesis Gas Underground

▶ SYNTHESIS GAS, the mixture of carbon monoxide and hydrogen that is the basic material for many industrial products, can be made by partial combustion of coal or lignite in underground seams and piped to the surface for use, in a process on which U.S. patent 2,466,945 has been issued to Frank C. Greene of Oakland, Calif.

In Mr. Greene's process, lateral borings made into the seam converge upon a central boring which is connected with an exhaust blower. After the underground fires have been started, input blowers on the lateral borings drive in air enriched with added oxygen to maintain combustion, and steam to be "cracked" by the glowing fuel. The resulting synthesis gas is pulled out by the exhaust blower.

Rights in the patent have been assigned to In Situ Gases, Inc., of Reno, Nev.

Titanate Insulators

▶ A DIELECTRIC, or insulating material, composed of vitrified titanates of barium and strontium, is protected by patent 2,467,169, issued to Eugene Wainer of Niagara Falls, N.Y., assignor to the National Lead Company.

Oil Flow Speeded

▶ A NEW ACID treatment to speed up oil flow in partially clogged wells is presented by Daniel J. Mullady of Kevin, Mont., for patents 2,466,673 and 2,466,674. In the first, hydrofluoric acid is used; in the second, hydrochloric. In both, either ammonium nitrite or ammonium nitrate is added, to hasten the reaction.

Ferronickel Process

▶ NICKEL, either pure or in the form of ferronickel, can be extracted from

low-grade ores hitherto not economically workable by a new process on which U.S. patent 2,468,103 has been granted to George W. Pawel of Norris, Tenn.

The ores are of the silicate type containing both iron and nickel. Unfortunately, they contain also considerable magnesium, which interferes with ordinary smelting processes, making them too costly.

In Mr. Pawel's process, the finer particles of ground ore can be smelted directly, yielding ferronickel ready for market. The coarser pieces are treated with hydrochloric acid solution, filtered, and neutralized with magnesia in two steps. The iron comes out as a hydroxide, which is routed to the ferronickel smelter, and the complex magnesium-nickel chloride, after another magnesia treatment, yields nickel hydroxide from which pure nickel can be extracted. Excess magnesia is reclaimed for the market.

Treatment For Gases

➤ INDUSTRIALLY useful compounds can be made out of otherwise "unmarriageable" gases by giving them a double radio-wave treatment within closed containers. One pair of electrodes discharges high-frequency waves, on the order of 60,000 to 300,000 cycles; the other pair sends out very low-frequency waves, even as low as 10 cycles. This treatment can be applied to various hydrocarbon gases, to ammonia, to alcohols and related compounds, etc. Used on ordinary air, it changes it from a mere mixture of nitrogen and oxygen into nitric oxide (NO).

Five patents, Nos. 2,468,173 through 2,468,177, have been issued to W. J. Cotton and E. T. Denton on various forms of apparatus in which this process can be carried out. Rights are assigned to the Koppers Company, Inc.

Food Preservatives

➤ DEHYDROACETIC ACID and its alkali salts are used as food and beverage preservataives in the process on which three patents, 2,474,227 through 2,474,229, were granted to G. H. Coleman and P. A. Wolf, assignors to the Dow Chemical Company.

Oil Extraction by Alcohol

➤ SOYBEAN OIL can be economically extracted with ordinary alcohol as a solvent, by a method on which U.S. patent 2,469,147 has been granted to two U.S. Department of Agriculture chemists, Dr. A. C. Beckel and P. A. Belter, of the Northern Regional Research Laboratory, Peoria, Ill. It is a continuous-process method; and other advantages are also claimed by the originators.

The ground beans are first treated with alcohol heated to near its boiling point. On cooling, some of the oil settles out at once, and can be drawn off for refining. The alcohol containing the balance of the oil, plus by-products, is re-heated with steam as it passes successively through two tall columns. In the first stage, practically all the remaining oil separates out in large drops, and settles out, to be drawn off. The second re-heating and settling stage brings out a mixture of sugar and lecithin, both of which have economic value. The inventors have assigned rights in their patent royalty-free to the government.

Excerpts From Silliman's Petroleum Report

First Analysis of Petroleum

A Classic of Chemistry

Taken from the new reprint of *The Frst Scientific Analysis of Petroleum:* A Chemical Classic That Touched off an Industry, printed by Paul H. Giddens, Meadville, Penna.

In the fall of 1853 George H. Bissel, a young lawyer of New York City, saw in the office of Darmouth's Chemistry Department a small bottle from an oil spring in Venango County, Pennsylvania. Impressed and excited over the possibilities of an illuminant, Bissell discussed the matter with his partner, Jonathan G. Eveleth. After they had inspected the oil springs they decided to form a company, buy the farm, and market the new product.

Eveleth and Bissel lacked the capital, however, to back this new enterprise and therefore enlisted the aid of some New York capitalists. These capitalists decided that before making an investment they should have an analysis made of the oil to determine the utility and the value of it. Thus Eveleth and Bissel engaged one of the great scientists of recent times, Professor Benjamin Silliman, Jr., of Yale College.

And it was Professor Silliman's analysis which proved to be the turning point in the petroleum industry, and from his analysis the value of oil was firmly established.

GENTLEMEN,

I herewith offer you the results of my somewhat extended researches upon the Rock Oil, or Petroleum, from Venango County, Pennsylvania, which you have requested me to examine with reference to its value for economical purposes.

Numerous localities, well known in different parts of the world, furnish an oily fluid exuding from the surface of the earth, sometimes alone in "tar springs," as they are called in the western U. S.; frequently it is found floating upon the surface of water in a thin film, with rainbow colors, or in dark globules, that may, by mechanical means, be separated from the fluid on which it swims.

In some places wells are sunk for the purpose of accumulating the product in a situation convenient for collection by pumping the water out. The oil exudes on the shores of Lakes and Lagoons, or rises from springs beneath the bed of Rivers. Such are the springs of Baku, in Persia, and the wells of Amiano, in the duchy of Parma, in Italy. The usual geological position of the rocks furnishing this natural product, is in the coal measures—but it is by no means confined to this group of rocks, since it has been found in deposits much more recent, and also in those that are older—but in whatever deposits it may occur, it is uniformly regarded

as a product of vegetable decomposition. Whether this decomposition has been effected by fermentation only, or by the aid of an elevated temperature, and distilled by heated vapor, is perhaps hardly settled. . . .

The Crude Product

The Crude oil, as is gathered on your lands, has a dark brown color, which, by reflected light, is greenish or bluish. It is thick even in warm weather—about as thick as thin molasses. In very cold weather it is somewhat more stiff, but can always be poured from a bottle even at 15 below zero. Its odor is strong and peculiar, and recalls to those who are familiar with it, the smell of Bitumen and Naphtha. Exposed for a long time to the air, it does not thicken or form a skin on its surface, and in no sense, can it be called a drying oil. The density of the Crude Oil is 882, water being 1000. It boils only at a very high temperature, and yet it begins to give off a vapor at a temperature not greatly above that of boiling water. It takes fire with some difficulty, and burns with an abundant smoky flame. It stains paper with the appearance of ordinary fat oils, and feels smooth and greasy between the fingers. It is frequently used in its crude state to lubricate coarse machinery. In chemical characters, it is entirely unlike the fat oils. Most of these characters are common to Petroleum from various places. In one important respect, however, the product of your lands differs from that obtained in other situations, that is, it does not, by continued exposure to the air, become hard and resinous like mineral pitch or bitumen. I have been informed by those who have visited the locality, that on the surface of the earth about the springs which furnish your oil, there is no crust or deposit of this sort such as I have seen in other situations where Petroleum or mineral tar is flowing. This difference will be seen to be of considerable importance, as it is understood and represented that this product exists in great abundance upon your property, that it can be gathered wherever a well is sunk in the soil, over a great number of acres, and that it is unfailing in its yield from year to year. The question naturally arises, of what value is it in the arts, and for what uses can it be employed? To enable you to answer these inquiries has been the object of my researches.

Examination of the Oil

To determine what products might be obtained in the oil, a portion of it was submitted to fractional distillation.[1] The temperature of the fluid was constantly regulated by a thermometer, the heat being applied first by a water bath, and then by a bath of linseed oil. This experiment was founded upon the belief that the crude product contained several distinct oils, having different boiling points. The quantity of material used in this experiment was 304 grammes. The thermometer indicated the degrees of the Centigrade scale, but, for convenience, the corresponding degrees of Fahrenheit's scale are added. The water

[1] Fractional distillation is a process intended to separate various products in mixture, and having unlike boiling points, by keeping the mixture contained in an alembic at regulated successive stages of temperature as long as there is any distillate at a given point, and then raising the heat to another degree, etc.

bath failed to distil any portion of the oil at 100° C. (=212° Fah.) only a small quantity of acid water came over. An oil bath, (linseed oil,) was then substituted, and the temperature was regularly raised by slow degrees until distillation commenced. From that point the heat was successively raised by stages of ten degrees, allowing full time at each stage for complete distillation of all that would rise at that temperature before advancing to the next stage. . . .

The uncertainty of the boiling points indicates that the products obtained were still mixtures of others, and the question forces itself upon us, whether these several oils are to be regarded as *educts,* (i.e., bodies previously existing, and simply separated in the process of distillation,) or whether they are not rather produced by the heat and chemical change in the process of distillation. The continued application of an elevated temperature alone is sufficient to effect changes in the constitution of many organic products, evolving new bodies not before existing in the original substance.

Use for Gas Making

The Crude Oil was tried as a means of illumination. For this purpose a weighed quantity was decomposed, by passing it through a wrought iron retort filled with carbon, and ignited to full redness. The products of this decomposition were received in a suitable apparatus. It produced nearly pure carburetted hydrogen gas, the most highly illuminating of all the carbon gases. In fact, the oil may be regarded as chemically identical with illuminating gas in a liquid form. The gas produced equalled ten cubic feet to the pound of oil. It burned with an intense flame, smoking in the ordinary gas jet, but furnishing the most perfect flame with the argand burner.

These experiments were not prosecuted further, because it was assumed that other products, now known and in use, for gas making, might be employed at less expense for this purpose, than your oil. Nevertheless, this branch of inquiry may be worthy of further attention.

Distillation

The results of the distillation at a regulated temperature in glass, led us to believe, that in a metallic vessel capable of enduring a high degree of heat, we might obtain a much larger proportion of valuable products. A copper-still, holding five or six gallons was therefore provided, and furnished with an opening, through which a thermometer could be introduced into the interior of the vessel. Fourteen imperial quarts (or, by weight, 560 ounces) of the crude product were placed in this vessel, and the heat raised rapidly to about 280° C, (= 536° Fah.,). At this high temperature the distillation was somewhat rapid, and the product was easily condensed without a worm. The product of the first stage was 130 ounces, (or over 28 per cent.,) of a very light colored thin oil, having a density of .792. This product was also acid, and as before, the acid was easily removed by boiling with fresh water. The temperature was now raised to somewhat about 300° C., (= 572° Fah.,) and 123 ounces more distilled, of a more viscid and yellow-

ish oil, having a density of .865. This accounts for over 43 per cent. of the whole quantity taken. The temperature being raised now above the boiling point of mercury, was continued at that until 170 ounces or over 31 per cent., of a dark brown oil had been distilled, having a strong empyreumatic odor. Upon standing still for some time, a dark blackish sediment was seen to settle from this portion, and on boiling it with water, the unpleasant odor was in a great degree removed, and the fluid became more light colored and perfectly bright. (It was on a sample of this that the photometric experiments were made.) The next portion, distilled at about 700° Fah., gave but about 17 ounces, and this product was both lighter in color and more fluid than the last. It now became necessary to employ dry hickory wood as a fuel, to obtain flame and sufficient heat to drive over any further portions of the residue remaining in the alembic.

It will be seen that we have already accounted for over 75 per cent. of the whole quantity taken. There was a loss on the whole process of about 10 per cent., made up, in part, of a coaly residue that remained in the alembic, and partly of the unavoidable loss resulting from the necessity of removing the oil twice from the alembic, during the process of distillation, in order to change the arrangements of the thermometer, and provide means of measuring a heat higher than that originally contemplated.

About 15 per cent. of a very thick, dark oil, completed this experiment. This last product, which came off slowly at about 50° Fah., is thicker than the original oil, and when cold is filled with a dense mass of pearly crystals. These are Paraffine, a peculiar product of the destructive distillation of many bodies in the organic kingdom. This substance may be separated and obtained as a white body, resembling fine spermaceti, and from it beautiful candles have been made. The oil in which the crystals float is of a very dark color, and by reflected light is blackish green, like the original crude product. Although it distills at so high a temperature, it boils at a point not very different from the denser products of the first distillation. The Paraffine, with which this portion of the oil abounds, does not exist ready-formed in the original crude product, but it is a result of the high temperature employed in the process of distillation, by which the elements are newly arranged.

I am not prepared to say, without further investigation, that it would be desirable for the Company to manufacture this product in a pure state, fit for producing candles, (a somewhat elaborate chemical process,) but I may add that, should it be desirable to do so, the quantity of this substance produced may probably be very largely increased, by means which it is now unnecessary to mention. . . .

Conclusion

In conclusion, gentlemen, it appears to me that there is much ground for encouragement in the belief that your Company have in their possession a raw material from which, by simple and not expensive process, they may manufacture very valuable products.

It is worthy of note that my experiments prove that nearly the *whole* of the raw product may be manufactured without waste, and this solely by a well directed process which is in practice, one of the most simple of all chemical processes.

There are suggestions of a practical nature, as to the economy of your manufacture, when you are ready to begin operations, which I shall be happy to make, should the Company require it — meanwhile, I remain, gentlemen,

Your ob't serv't,

B. SILLIMAN, JR.

Prof. of Chemistry, in Yale College.
New Haven, April 16, 1855.

—Reprinted by special permission of THE SATURDAY EVENING POST
Copyright 1949 by The Curtis Publishing Company

▸ "AND ANOTHER *thing, Miss Hastings. In the future, when you make out your laboratory reports, will you please use the phrase 'ultramicroscopic' in preference to 'itty-bitty'?"*

Frivolous Effervescence and Caustic Comment

by Our Readers

➤ "What would be the exact formula," Miss R. M. B., Chambersburg, Pa., wants to know, "for coloring crepe paper or other materials so as to give the weather conditions, blue for fair weather, lavender for change, pink for rain? You use cobalt chloride, but my solution is too blue and does not turn lavender and only slightly pink."

The chemical which gives the most striking color effect with changes of humidity is cobalt chloride. Its effectiveness can be increased to some extent by the addition of a hygroscopic salt which tends to absorb moisture from the air. Some of the silica gels are excellent for this purpose.

Normally it will suffice merely to dip the piece of cloth in a solution of cobalt chloride in water, to which some adhesive such as mucillage may be added, if desired. Let the cloth dry and it will be ready for use.

• • •

➤ I received the "Show Book Copy." It is a credit to its authors and will be invaluable to me.

Sister F., Louisville, Kentucky.

➤ I will be grateful if you will let me know if the Table of Elements you published last year is still available. Also I would like to say how pleased I am with the Summer Show Book Edition.

P.J.B., County Cork, Eire.

The Editors appreciate the kind words about the Chemistry Show Book (a limited number of which are still available). A new edition of the Periodic Table will be available shortly, with the changes announced at the 116th Meeting of the A.C.S.

• • •

➤ "I am a constant reader of the Chemistry magazine and find it very interesting and plain reading."

J. M., Freeland, Pa.

• • •

➤ I am very sorry, that I cannot be longer subscriber of your magazine. It has a very good quality and we would be happy if we in Czechoslovaquia had such a one to direct our chemical youth. But "Chemistry" is not what I need, i.e. a pure scientific, special magazine, carrying original publications, not a popularizing one. Therefore I must ask my friends in U.S.A. to change the subscription. I write some reports about the news in chemistry in Czech magazines and it is not easy, to write if original work is wanting. If you have interest in the structure and position of the European science, especially on the advantages of the gratest Czech "star"—namely polarography—I am ready to contribute to your "Chemistry."

I hold you up as a model for our magazines.

Yours sincerely, P. Z. Prague.

Improvement in Bergius Process Reported by U. S. Bureau of Mines

Coal Hydrogen Simplified

▶ THE COST of making synthetic gasoline and oil from coal may be significantly reduced by a new method described by five United States Bureau of Mines chemists at the recent meeting of the American Chemical Society.

The new technique, which eliminates part of the relatively complicated Bergius-I.G. process developed by the Germans to offset wartime petroleum shortages, is under investigation at the Bureau's Synthetic Liquid Fuels Laboratories at Bruceton, Pa., according to a paper by E. L. Clark, M. G. Pelipetz, H. H. Storch, S. Weller and S. Schreiber. Dr. Storch is chief of the Bureau's Synthetic Liquid Fuels Research and Development Division.

Explaining that the principal difference between oil and coal is that the former contains more hydrogen, the paper says the German process formed liquid fuels by adding hydrogen to coal, accomplishing the addition by suspending fine particles of coal in an oil and treating this mixture with hydrogen gas under very high pressures at high temperatures.

Preliminary work at the Bruceton laboratories has shown that the hydrogenation of coal, as it is called, can be effected without suspending the coal particles in oil. This consequently eliminates the need of equipment for preparing the oil initially for use in the process, and for separating the oil from the resulting mixture. The space formerly occupied by the oil thus becomes available for the conversion of more coal.

Moreover the improved process requires only operating equipment and techniques already familiar to the American petroleum industry, so that no heavy, specially designed and expensive equipment is necessary, such as that required to contain the high pressures used in the Bergius process.

Hydrogenation is accomplished in the new process by blowing hydrogen gas up through a bed of coal particles at such a rate that the coal particles "dance about in a manner closely resembling that of a boiling fluid." Such a technique, commonly described in industry as the "fluidized technique," permits the chemical addition of hydrogen to coal at much lower pressures than those demanded by the Bergius process.

Under the conditions used in the fluidization process, the report continued, some of the coal is not converted to oil and gasoline but, instead, releases hydrogen and other gases and becomes "char" or coke. Although this may at first appear to be a disadvantage, it is really advantageous, for several reasons.

The hydrogen released by this coal is immediately available for reaction with other unreacted coal to form oil and gasoline. This means that less hy-

drogen gas has to be compressed and supplied to the process, and a considerable saving results. The coke itself provides an ideal fuel to supply the power requirements of the plant which would normally be met by burning coal anyway. As the original coal loses practically all of its sulfur upon being converted to coke under hydrogenating conditions, this coke is particularly valuable if it can be used as a raw material in a nearby plant which requires a mixture of gases containing virtually no sulfur.

Many severe engineering difficulties must be solved, however, before a new and cheaper process for the hydrogenation of coal to oil and gasoline is realized. The problem of injecting dry coal particles into a system under pressure is a severe one. The Bruceton laboratories have made a very satisfactory start toward the solution of this and many other engineering problems related to such a process, but the nature of the work so far is only preliminary and much remains to be done.

Gelsoy is Soybean Product

▶ THE soybean, already one of America's top-notch crops producing oil, meal, food, feeds and fodder, is now yielding a tight-sticking glue, dubbed Gelsoy, which is also a valuable food product.

It is said to be the first vegetable protein gel. As a glue, it could be used on envelopes which could not be "steamed" open. The heat of the steam will simply make the envelope flap stick tighter. Gelsoy glue will stick to tin, glass and other surfaces. It may play a big part in sticking labels on preserved foods in cans, jars and pottery containers. Many other uses are possible.

As a food, because of its bland taste and its whipping and gelling properties, many uses are possible. It is a nutritious substance, about half soybean protein and half carbohydrate, that has many of the qualities of egg white. It can be whipped into frothy meringues for pies, is useful in cookie and cake fillings, and may find its way into ice creams, candies, prepared cold meats, soups and other foods.

The value of Gelsoy as a gelling agent for food products and as an adhesive is a discovery credited to Mrs. Letta I. DeVoss, scientific aide in the Northern Regional Research Laboratory of the U. S. Department of Agriculture at Peoria, Ill. Laboratory scientists had derived the new substance from the soybean, and Mrs. DeVoss started cooking a batch to test its whipping qualities. When it reached a temperature of about 190 degrees Fahrenheit it formed a jelly-like mass. For this discovery, she was given a Superior Service Award by Secretary Charles F. Brannan for the Department of Agriculture.

Common salt has long been used to keep damp or undercured hay from heating, but it is not a substitute for proper curing.

Coal Needed For Food and We'll Eat Our Dirty Clothes of Rayon

Chemistry Will Change World

▸ *We look ahead into the future of our civilization and see what chemistry might contribute to the world of tomorrow. There are many rather obvious things that might happen based on the developments that have already been made — more use of plastics, application of lighter metals, exploitation of atomic energy, and a host of other possibilities. But the Adventures in Science guest speaking on the Science Service radio program over the Columbia Broadcasting System, is not content with the obvious approach, for he has been a pioneer in the development of a new class of materials, the silicones, that combine carbon and silicon (most familiar to you in sand) to make a range of substances of great industrial usefulness. He is Prof. Eugene G. Rochow, associate professor of chemistry at Harvard and until two years ago a General Electric research chemist. His fellow chemists have honored him with the prized Baekeland medal.*

ANNOUNCER: Chemistry has added immense wealth to our world and opens the way to even greater luxuries for mankind in the future.

ROCHOW: I'm not as optimistic as you are. Perhaps you will agree with me that human life is the most valuable thing on earth. If that is true, we treat our valuables in a strange fashion. After putting an end to about twenty million lives by the fearful man-made instrument called war, we have left many of our surviving relations without the barest necessities of food, clothing and shelter. In a world that is fully capable of supporting at least its present population in a handsome way, we see shortages in the supply of raw materials, a prodigious waste of irreplaceable natural resources, a lack of agricultural fertilizer and machinery to help fill the world's breadbasket, and a decided ineffectiveness in treating even many of the most common bodily ills.

ANNOUNCER: That's a viewpoint that is thought provoking. What can we do?

ROCHOW: The paramount issue to be settled, of course, is that of war and peace, and here the chemist can act in his first responsibility as a citizen. On the matters of food supply, materials of construction, medical chemistry, and conservation of natural resources the chemist can do much more than other citizens, for he can apply his training and knowledge.

ANNOUNCER: But surely we have enough of many raw materials of our civilization, such as coal and iron.

ROCHOW: I'm sorry to say that we haven't. True, we have used only two percent of the coal in this country, but 58% of the oil is used up, and gone forever. We have used and largely wasted 31% of the iron ore. We are poor in copper, with only 40% left now. Only 34% of the zinc we had now remains, only 30% of the

tungsten, 15% of both lead and silver and a mere 3% of the mercury.

ANNOUNCER: But we can make gasoline, lubricating oil and fuel oil out of coal. So we need not worry too much about using up our petroleum, except that it will cost us more to run our automobiles.

ROCHOW: True enough, we can make oil out of coal. The suitable parts of our coal reserve would give us liquid fuel for a thousand to three thousand years at our estimated 1965 consumption. But we have always underestimated our future needs and coal may provide only a hundred years of liquid fuel supply at the rate that we may be consuming it in 1995, less than 50 years from now. Also this is not the only use for coal. We need it for making synthetic organic products. Iron and steel manufacture need it. It is used for power and heating. And, what is more important, it may be needed for food.

ANNOUNCERS For food, Dr. Rochow? Surely we can't eat coal.

ROCHOW: Not directly, but fats of the future may be made from coal and may be the most important use of coal for our descendants. What we should do is to stop thinking about more ways to exhaust our resources and to start thinking about ways to live on the energy supplies and the materials that are inexhaustible.

ANNOUNCER: I'm beginning to think that everything we do is wrong from the standpoint of conservation of our resources.

ROCHOW: Well, it is rather absurd what we do, isn't it? We scrape together high concentrations of substances like steel, aluminum and rubber in the form of manufactured articles, wear away only a small part of them and then throw the rest away. Our city dumps and automobile cemeteries waste a large amount of valuable materials. The present-day automobile is one of our worst devices; it requires much scarce and valuable metal, won from the ores so laboriously. When a few ounces of metal are worn from the 3000 pounds of motor and running gear, the machine is pronounced unfit and discarded. I should think that the automobile manufacturer would want to *loan* the metal content of a car to the purchaser on a deposit basis, rather than sell it outright and rely upon the haphazard junking system to return part of it as scrap. Much precious material is carried down to sea as sediment or in solution. We are eroding our land, destroying our soil, wasting our forests and using our mineral deposits. We should pay attention to using what can be replaced instead of what, once used, is gone forever.

ANNOUNCER: But how can we know, Dr. Rochow?

ROCHOW: You can figure it out. A Yale scientist has worked out what he calls a conservation quotient, or c.q. Electricity made from water power would have a conservation quotient of almost a hundred, but if it is made from coal, the fossilized sunshine of past ages, its conservation quotient is zero.

ANNOUNCER: Gasoline from petroleum would have a c.q. of zero, but alcohol from molasses would have a c.q. of close to a hundred. I think I understand.

ROCHOW: Yes. It is a helpful way of looking at the problem. Of course, it is not just what is renewable and what is not. Plant life can be grown again and again, but the supplies of nitrogen, phosphorus, potassium and other elements must be taken into consideration. It looks as though we could get them from the air and the sea.

ANNOUNCER: Now, Dr. Rochow, what about food for the future?

ROCHOW: If we can solve the problems along the lines that I believe we can, a population of the United States of about one billion people could probably be fed.

ANNOUNCER: That is about seven times the people now in this country.

ROCHOW: That's right, and a world population of 15 billions would not seem unreasonable. But let me warn you that our descendents on such a crowded earth wouldn't be eating hot dogs and ice cream. They would be too expensive from the standpoint of chemical resources. They will have to satisfy their appetites with music and literature, it has been suggested.

ANNOUNCER: I am not sure that I would like that. What will they eat, then?

ROCHOW: Ordinary farming such as we practice now would not support them. It takes over a ton of food a year grown on nearly five acres of land to support a person today. I expect that they would have to eat wood, in large measure.

ANNOUNCER: But human beings can't eat wood, Dr. Rochow.

ROCHOW: Not directly. But the only way to feed the billions will be to use the world's trees for feeding people instead of using wood for houses and other building purposes. A tree is able to get its mineral nutrients from the subsoil, and hence grows even in rocky area (if there is enough water) because it taps the unleached depths where the proportion of dissolved salts is high. It absorbs great quantities of carbon dioxide, liberates much oxygen to complete the oxygen cycle, evaporates as much as several hundred gallons of water per day which would otherwise carry dissolved minerals to the sea, and is altogether an admirable thing to have around. Unfortunately we cannot digest cellulose, as can the ruminants and many other animals. We could get all our carbohydrate requirements by hydrolysing the cellulose to simple digestible sugars, or by putting microorganisms to work to make mono- and disaccharides for us. A people used to highly purified sucrose (and even pure dextrose) should have no objection to other pure sugars from wood. A larger problem for chemists remains after converting the cellulose, however, in utilizing the lignin that constitutes about 40% of wood.

ANNOUNCER: Very well, that takes care of the carbohydrates of the diet of the future. What about the meat?

ROCHOW: No meat. But there must be protein for the future masses. That offers more difficulty. It seems certain that meat and eggs as sources of protein will gradually vanish, for a beef steer converts only about 12% of its food to meat and does worse at it when poorly fed. It is much more sensible (if less fun) to feed the plant pro-

teins to people directly, as the British have found in the last decade.

ANNOUNCER: What if we run out of vegetable protein?

ROCHOW: After plant proteins become too scarce, and if fish do not satisfy the appetite and taste, synthetic amino acids seem to provide the only answer.

ANNOUNCER: What about fats?

ROCHOW: Fats are not so easily obtained by microbiological activity, nor do we have enough from plant sources. They can be made synthetically, however, and the Germans developed a satisfactory product during the recent war by converting coal to edible fats. It is a process like this that puts the food industry in competition with other industries for the coal reserve.

ANNOUNCER: Now, Mr. Rochow, what about clothes of the future.

ROCHOW: Clothing needs are much more easily satisfied than those of food. If we are to have plenty of cellulose, we may as well have rayon textiles rather than the supposedly less comfortable or durable paper clothes that Bellamy imagined in his book of the last century: *Looking Backward*. Only about 15 pounds per year of cellulose would be required for each person, in contrast with the food requirement, and it need only be loaned; instead of remaking paper clothes (as in *Looking Backward*) we could convert pure cellulose used clothes to edible products.

ANNOUNCER: You mean we'd eat our dirty clothes.

ROCHOW: Exactly. Wool would be out because of the extreme amount of food required to raise it, and furs would have to be synthetic unless the polar bear and the seal increased their output. Leather will disappear with meat, and the plastic which is geochemically cheapest and has the highest conservation quotient will take over.

ANNOUNCER: How will we get about in the crowded future, Dr. Rochow? Ordinary automobiles of steel run by gasoline seem to be too expensive for our resources.

ROCHOW: Yes, that's right. There must be increased use of magnesium, of which there is plenty in the sea, and it will be our prime structural metal. There must be a power source from materials that are renewable, if our future populations are to move around much or very fast.

ANNOUNCER: Now, what about a roof over the heads of the populations of the future?

ROCHOW: For housing we are almost certainly driven to ceramic structures, with a very low minimum of wood and not even much steel. In Bermuda houses today are built out of the soft Aeolean limestone on the building lot itself. Here in the United States we have less obliging rocks and subsoils, but given a great deal of cheap power they could be fused into building blocks on the site. Automatic processing machines might even be built to deliver bricks from the excavated material from your basement. Schools and public building now are made in much this way, except that the bricks and glass blocks are transported and much steel, asphalt and similar material is used along with them.

CHEMISTRY Teaching Aids for You

- **Group Subscriptions to CHEMISTRY**, state number of copies wanted. 10 or more copies in one bundle for 1 year at $1.75 each _____

- **Chemistry SHOW BOOK**, state number of copies wanted. Durably bound in blue cloth, $2.00 per copy _____

- **Periodic TABLE OF ELEMENTS**, new edition, state number wanted. 25 cents each, or 10 copies for $1.00 _____

- **THINGS of Science**, one experimental kit each month, $4.00 per year for each membership. No. memberships _____

- **FUNdamentals of Science**, large kits with material for experiments, sent postpaid in the United States, at $4.95 each.

  BLACK LIGHT AND GLOWING MATERIALS, state number wanted _____

  ELECTRICITY AND MAGNETISM, state number wanted _____

  SOILLESS GARDENING, state number wanted _____

- **BOOKS** from any American publisher may be ordered through Science Service Book Department, postpaid at the regular list price. Give Title, Author, Publisher, Price.

To **CHEMISTRY**, 1719 N St. N.W., Washington 6, D.C.

In payment for the above order, please find $_____

Name _____

Address _____

_____

CITY ZONE STATE